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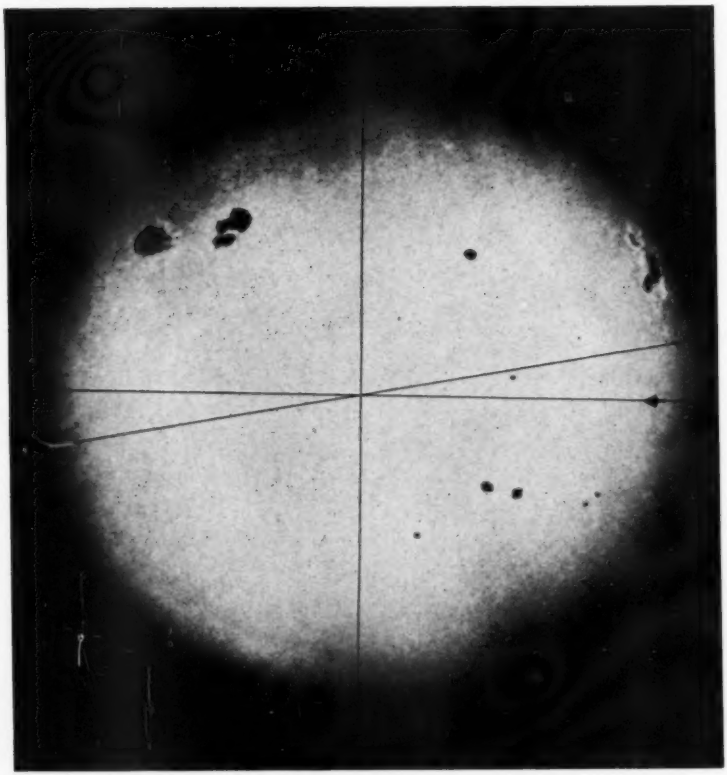

Fig. 3.—The Disc of the Sun, July 31, 1937.

PLATE III

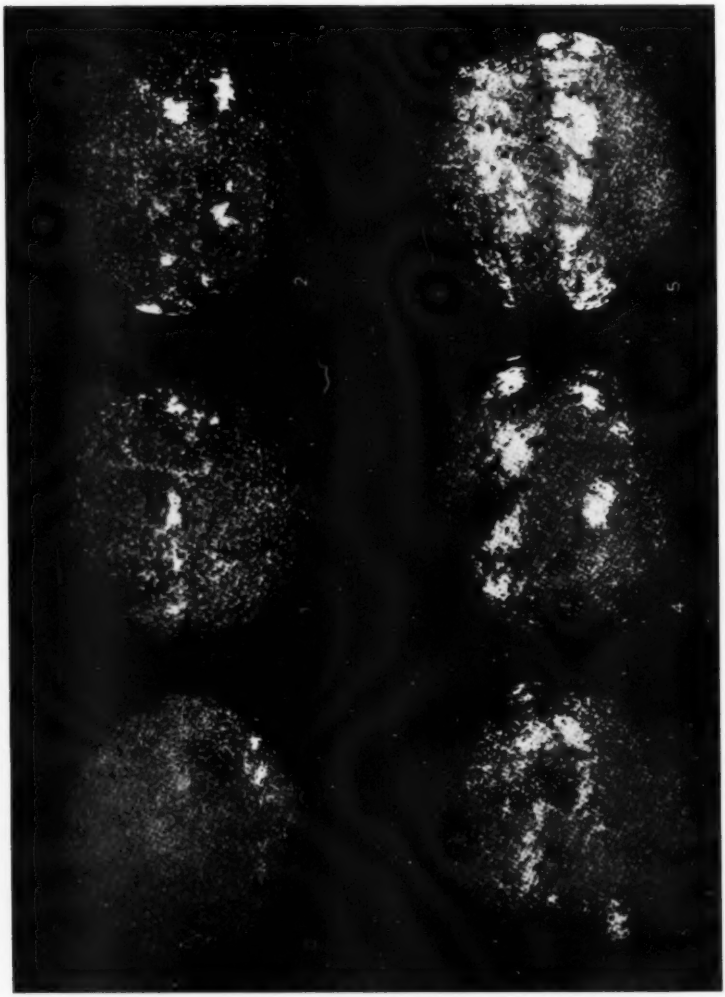

Fig. 4.—Mount Wilson Spectroheliograms showing the Solar Disc in the Calcium lines.

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Vol. XXXII, No. 3 MARCH, 1938 Whole No. 272

SUNSPOT INFLUENCES

By Ralph E. De Lury

(Annual Address of the President)

IT is a common impression that the weather and living conditions vary greatly from season to season and year to year. Records show serious and widespread departures from the normal or average conditions expected from the earth's rotation on its tilted axis and its orbital motion around the sun. The daily and yearly factors change so slowly that they may be regarded as constant over a considerable span of years, and consequently the abnormalities are attributed to other variable astronomical factors.

The search for the causes of the electromagnetic, meteorological and vital variations from normal has been directed primarily to our variable life-giving sun, long known to be inconstant as indicated by its changing spottedness. Or, quoting from an article[1] on "Sunspots and the Weather" in this Journal: "Variations in the quantity or quality of the radiation received by the earth from the sun must produce changes in the weather. Differences in the energy received arise from changes in the sun or the intervening space. The important problem of determining the nature and extent of these variations and their terrestrial consequences has for years attracted alike the astronomer, the meteorologist, and the economist, and quite naturally the greatest attention has been given to the most obvious change in the sun, namely, the variations in its 'spots' ". The record of sunspots has been kept for many years and it is a simple matter to compare their variations with those in other phenomena.

[1] *Jour. R.A.S.C.*, 19, 293-298, 1925.

Sunspot Records and Characteristics

Large sunspots or groups of spots are visible to the unaided eye when the sunlight is sufficiently weakened by atmospheric haze. Doubtless they have been observed for ages, but the earliest known records of their occurrences are those made by the Chinese:

Chinese records—From the monumental encyclopaedia of Ma Twan Lin, records of sunspots from A.D. 301 to 1205 were translated by John Williams,[2] and the list was extended to the period A.D. 188 to 1638 by S. Hirayama.[3] There are more than a hundred records of sunspots and they are of scientific interest and value. The Chinese believed they had an influence on terrestrial affairs, though their logic was flavoured with a little more superstition than hampers us to-day; thus, quoting Williams, ". . . in several instances the death of an Emperor, or some other important personage, is said to have shortly followed the appearance of a spot". A few examples are selected some of which will be referred to later:

A.D. 188, Feb. 14.	The colour of the Sun reddish yellow. Fleckle in the Sun, bird-shaped.
374, Apr. 7.	2 fleckles in the Sun.
499, Jan. 31.	3 fleckles in the Sun.
1005, Jan. 10.	2 fleckles.
1077, Mar. 13.	Fleckle like apple.
1077, Apr. 4.	Continuously seen.
1078, Mar. 17.	Fleckle in the Sun.
1078, Apr. 4.	" " " "
1079, Jan. 17.	" " " " , apple-shaped.
1079, Mar. 25.	" " " "
1120, Feb. 25.	" " " "
1120, June 14.	" " " "
1122, Jan. 17.	" " " "
1616, Oct. 10.	Dark light in the Sun.
1618, Aug. 17.	Fleckle in the Sun.
1618, Aug. 19.	" " " "
1624, Mar. 15.	" " " "
1638, Dec. 10.	" " " "

[2]John Williams, *Monthly Notices*, 33, 370-375, 1873.
[3]S. Hirayama, *Observatory*, 12, 217-219, 1889.

Telescopic records—In Europe shortly after the invention of the telescope, sunspots were observed and the records now cover a period of about 330 years, with systematic recording by photography for more than 60 years. The telescopic observation of the Sun revealed the following facts: dark and bright spots appear, vary in size and shape during an existence of days, weeks and months and disappear; individual dark spots are frequently nearly circular in shape having a dark centre (umbra) surrounded by a shaded ring (penumbra), and they range in size up to about 50,000 miles in diameter; pairs of dark spots are frequently seen and these often develop into groups of several spots not uncommonly extending 150,000 miles or more; large bright areas (faculae) usually accompany the dark spots, though they occur also without the dark spots; the surface of the Sun is flocculated by many bright clouds (flocculi) and pocked by darker markings (pores), the whole changing system indicating turbulence in the hot solar gases; the march of sunspots across the solar disc from east limb to west limb in about two weeks as seen from the earth was early interpreted as due to the rotation of the sun; the axis of rotation of the sun was found to be inclined 7°15′ to the ecliptic, the earth in its orbital motion ascending through the solar equatorial plane early in June (Carrington); the dark spots usually occur within 40° north or south of the solar equator, those nearer the equator making the complete rotation in less time than those at the higher latitudes, the average period of rotation being about 25.4 days; and both sunspots and faculae were found to vary in numbers, being scarce in some years and numerous in other.

Periodicity—About a century ago it was definitely realized that there was a cycle of about 11 years in the numbers of sunspots (Schwabe); and later that there was a drift in their latitudinal positions, the spots when scarce appearing at the higher latitudes and drawing nearer to the equator during the progress of the cycle to the next minimum in numbers (Spörer). Suspicion arose that variations in the aurora borealis and terrestrial magnetism accompanied this cycle. There was renewed interest in recording sunspots and their motions.

Years later the records were put on a systematic basis by Wolf's determinations of monthly sunspot "relative numbers", derived by

using an arbitrary formula, lessened slightly for observations made by others when using telescopes of higher power than he employed.

10 × (number of groups and separate spots) + (number of individual spots in groups and separate),

Wolf investigated the early records assigning approximately the date of sunspot minima and maxima up to 1749, after which time the records enabled him to derive continuous monthly relative numbers. He continued the determinations throughout his lifetime. After 1893 Wolfer derived the numbers, and in recent years Brunner has issued quarterly reports of the monthly relative numbers and other statistics of the solar surface from the Bureau of the International Astronomical Union, Zürich, using observations of co-operating observatories throughout the world.

In Table I are given the assigned dates of minima and maxima of sunspots with the periods, P between successive minima and P′ between successive maxima, and the intervals between minimum and

TABLE I.—Assigned Dates of Minima and Maxima of Sunspots, Periods, P and P′, and Intervals between Minimum and Maximum, and between Maximum and Minimum.

Minima	P	Maxima	P′	Minima	P	Maxima	P′	Minima	P	Maxima	P′
1610.8				5.3	11.2	1750.3		1878.9		8.3	13.3
4.7	8.2	1615.5		1755.2		4.9	11.2	5.0	10.7	1883.9	
1619.0		3.5	10.5	6.3	11.3	1761.5		1889.6		5.7	10.2
7.0	15.0	1626.0		1766.5		5.0	8.2	4.5	12.0	1894.1	
1634.0		8.0	13.5	3.2	9.0	1769.7		1901.6		7.5	12.3
5.5	11.0	1639.5		1775.5		5.8	8.7	4.8	11.8	1906.4	
1645.0		5.5	9.5	2.9	9.2	1778.4		1913.4		7.0	11.2
4.0	10.0	1649.0		1784.7		6.3	9.7	4.2	10.2	1917.6	
1655.0		6.0	11.0	3.4	13.6	1788.1		1923.6		6.0	10.9
5.0	11.0	1660.0		1798.3		10.2	17.1	4.9	10.3	1928.5	
1666.0		6.0	15.0	6.9	12.3	1805.2		1933.9		5.4	
9.0	13.5	1675.0		1810.6		5.4	11.2				
1679.5		4.5	10.0	5.8	12.7	1816.4					
5.5	10.0	1685.0		1823.3		6.9	13.5				
1689.5		4.5	8.0	6.6	10.6	1829.9					
3.5	8.5	1693.0		1833.9		4.0	7.3				
1698.0		5.0	12.5	3.3	9.6	1837.2					
7.5	14.0	1705.5		1843.5		6.3	10.9				
1712.0		6.5	12.7	4.6	12.5	1848.1					
6.2	11.5	1718.2		1856.0		7.9	12.0				
1723.5		5.3	9.3	4.1	11.2	1860.1					
4.0	10.5	1727.5		1867.2		7.1	10.5				
1734.0		6.5	11.2	3.4	11.7	1870.6					
4.7	11.0	1738.7									
1745.0		6.3	11.6								
Means:	11.18		11.23		11.24		10.94		11.00		11.58
r :	±1.40		±1.23		± .96		±1.83		± .57		± .83
ro :	± .40		± .38		± .28		± .55		± .26		± .37

Means for the last 16 cycles: P, 11.17±.22, P′ 11.14±.39 years; and interval, Minimum to Maximum 4.6 years, and Maximum to Minimum 6.6 years.

the next maximum and between maximum and the following minimum. The dates are arranged in three groups of increasing reliability, the second comprising the period of the monthly numbers to 1870 after which time the visual observations were supplemented by photography.

TABLE II.—5 Cycles, 1878-1932, of Wolf-Wolfer-Brunner Yearly Means of Monthly Sunspot Relative Numbers; and Greenwich Yearly Means of the Daily Areas of Umbrae, Whole Spots and Faculae in Millionths of the Sun's Visible Hemisphere.

SUNSPOT RELATIVE NUMBERS

Year	0	1	2	3	4	5	6	7	8	9	10	11	Means
1878	3.4	6.0	32.3	54.3	59.7	*63.7*	*63.5*	52.2	25.4	13.1	6.8		34.6
1889	6.3	7.1	35.6	73.0	*84.9*	78.0	64.0	41.8	26.2	26.7	12.1	9.5	38.8
1901	2.7	5.0	24.4	42.0	*63.5*	53.8	*62.0*	48.5	43.9	18.6	5.7	3.6	31.1
1913	1.4	9.6	47.4	57.1	*103.9*	80.6	63.6	37.6	26.1	14.2			41.2
1923	5.8	16.7	44.3	63.9	69.0	*77.8*	65.0	35.7	21.2	11.1			41.1
Means	3.9	8.9	36.8	58.1	76.2	70.8	63.6	43.2	28.6	16.7	8.2	6.6	37.3

AREAS OF UMBRAE

Year	0	1	2	3	4	5	6	7	8	9	10	11	Means
1878	5	11	85	149	*189*	175	148	101	50	26	14		87
1889	13	16	86	186	*234*	*231*	169	90	88	64	18	17	101
1901	9	10	51	67	*163*	114	*160*	106	124	49	12	7	73
1913	1	31	137	135	*247*	188	182	112	79	45			116
1923	10	46	141	217	186	*244*	*245*	106	57	35			129
Means	8	23	100	151	204	190	181	103	80	44	15	12	91

AREAS OF UMBRAE + PENUMBRAE

Year	0	1	2	3	4	5	6	7	8	9	10	11	Means
1878	24	49	416	730	1002	*1155*	1079	811	381	179	89		538
1889	78	99	569	1214	*1464*	1282	974	543	514	375	111	75	608
1901	29	62	340	488	*1191*	778	1082	697	692	264	64	37	477
1913	7	152	697	724	*1537*	1118	1052	618	420	252			658
1923	55	276	830	1262	1058	*1390*	1242	516	275	163			707
Means	10	128	570	884	1250	1145	1086	637	456	247	53	22	543

AREAS OF FACULAE

Year	0	1	2	3	4	5	6	7	8	9	10	11	Means
1878	90	151	977	1733	*2154*	1856	2057	1496	579	301	236		1057
1889	131	304	1412	*3270*	2404	1877	2278	1410	1149	891	337	180	1307
1901	29	178	970	1761	*2612*	2320	1999	2098	1353	971	459	210	1247
1913	95	454	1521	1785	*2305*	1882	1729	1219	739	415			1214
1923	222	575	1750	*2556*	2212	*2589*	*2567*	1630	801	400			1530
Means	113	332	1326	2221	2337	2105	2126	1571	924	596	344	195	1161

From Table I it is seen that the mean of 29 values of P is 11.14 years, and of 28 values of P′, 11.18 years, with mean values of the interval between minimum and succeeding maximum, and that between maximum and the following minimum, of 5.0 and 6.1 years, respectively. If we consider only the interval covered by the record of monthly relative numbers, between 1750.3 to 1933.9 the

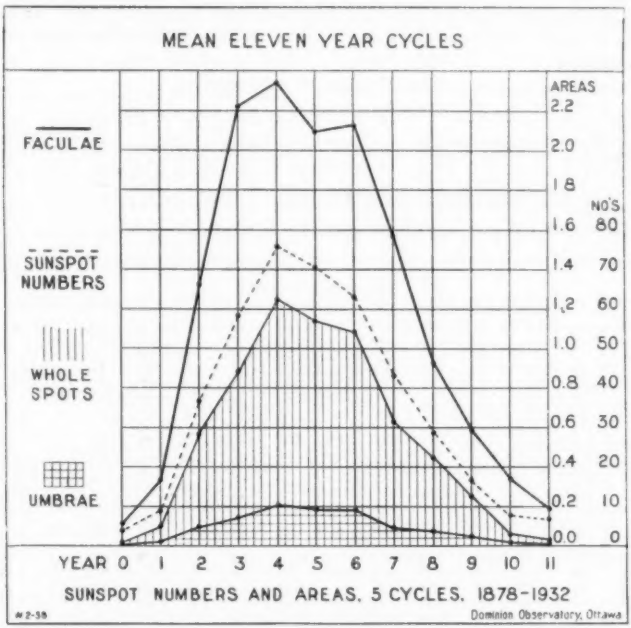


Fig. 1

means for 16 values are, P, 11.17±.22 years, and P′, 11.14±.39 years; and the intervals are in the mean, minimum to maximum, 4.6 years, and maximum to minimum, 6.6 years.

Greenwich Observatory has published regularly the areas of umbrae, whole spots and faculae from the systematic photographic records made at Greenwich, Dehra Dûn, Mauritius and later Kodaikanal and the Cape observatories. In Table II are given yearly

means[4] of these areas expressed as millionths of the sun's visible hemisphere, along with the yearly means of the Wolf-Wolfer-Brunner monthly sunspot relative numbers, for the last 5 completed cycles, 1878-1932. The means of the 5 cycles of each are charted in Fig. 1, the areas expressed in thousandths of the visible hemisphere. It will be seen that despite the arbitrary nature of the sunspot "relative numbers" their mean cycle is surprisingly proportional to that of the areas. The means of the yearly values reveal that the ratios of the relative numbers to the areas, in millionths of the sun's visible hemisphere, of umbrae, whole spots and faculae are as 0.4:1:6:13. The diameter of a "whole spot" is 2.5 times that of the umbra, rather larger than appears in the average separate spot.

The average yearly values for the mean of the 17 cycles, 1749-1936, comprising the whole monthly record, are as follows for the years of the cycle from minimum on, all those numbers 11 or more years after minimum being averaged in the last column:

Year:	0	1	2	3	4	5	6	7	8	9	10	11
Number:	5.9	14.7	44.7	77.0	83.9	78.4	67.3	50.1	36.4	25.0	17.8	9.7

This mean cycle is charted in Fig. 2 from 1933.9, the time of the last minimum of sunspots, to 1945.1, along with the yearly means of the monthly relative numbers of the last 5 years and the monthly numbers so far known in the present cycle. The peak of the mean curve lies about the end of 1937. From the numbers to date it would seem that the present cycle will have an abnormally large maximum, or possibly that the maximum is already past. On the other hand the mean interval, 4.6 years, would place the next maximum at the middle of 1938. The mean cycle can be taken as representing the coming spottedness with a fair degree of probability. In this connection it should be noted from an inspection of the yearly numbers of Table II that the yearly values do not fix the maxima definitely in the various cycles, the numbers and the areas sometimes indicating different years for the maximum. The minimum years are relatively more definitely determined.

In Table III are given the monthly sunspot relative numbers for

[4] *Monthly Notices*, 49, 381, 1889; 61, 535, 1901; 76, 402, 1916; 85, 1007, 1925; and 94, 870, 1934.

the last 3 completed cycles, 1901-1932. An inspection of the table will reveal considerable irregularity in the monthly numbers during the progress of the cycles, an irregularity of sufficient magnitude to be reflected in any sunspot influences which may exist.

Before considering the mechanism by which the changes in the sun cause variations in the solar system, a brief statement concerning the nature of sunspots will be given.

Vortex structure—Separate sunspots viewed near the centre of the solar disc usually appear circular in outline with the umbra central

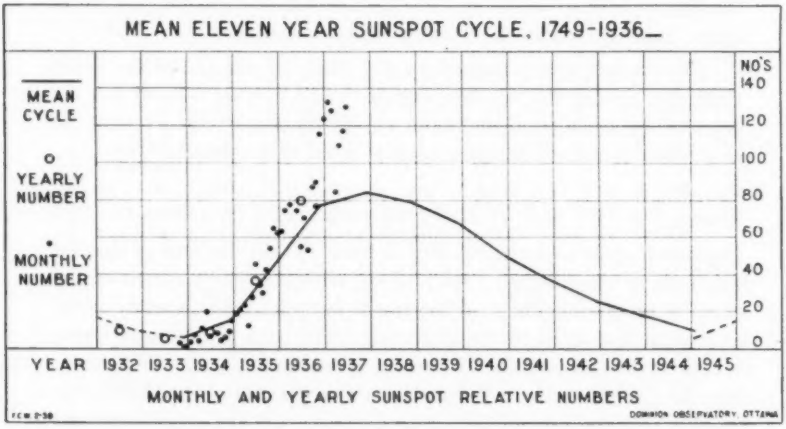


Fig. 2

inside the penumbral ring. Near the limb, of course, they appear oval in form, and the near side of the penumbra becomes invisible with the umbra visible over the edge, while the far side of the penumbra is visible. This indicates a shape similar to a funnel with the umbra lower in the solar atmosphere than the penumbra. A well defined circular spot frequently retains its form for more than a rotation of the sun. The form and stability of spots suggest that they are vortices. Associated pairs of spots when photographed in the light of a hydrogen spectrum line have shown (Mount Wilson) radical markings curving out to great distances from the spots, indicating whirls

of opposite direction and covering a wide region in the high-level hydrogen atmosphere above the pair of spots. This suggested that the pair of sunspots are opposite ends of a U-shaped vortex (Hale); or possibly that they are the ends of a broken vortex tube (Bjerknes); while a third possibility is that vortices rotating in opposite directions may tend to drift together or attract one another. Many such associated pairs of sunspots occur. They frequently develop into large groups of sunspots.

TABLE III.—Observed Sunspot Relative Numbers.

1901-1912

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1901	0.2	2.4	4.5	0.0	10.2	5.8	0.7	1.0	0.6	3.7	3.8	0.0	2.7
1902	5.2	0.0	12.4	0.0	2.8	1.4	0.9	2.3	7.6	16.3	10.3	1.1	5.0
1903	8.3	17.0	13.5	26.1	14.6	16.3	27.9	28.8	11.1	38.9	44.5	45.6	24.4
1904	31.6	24.5	37.2	43.0	39.5	41.0	50.6	58.2	30.1	54.2	38.0	54.6	42.0
1905	54.8	85.8	56.5	39.3	48.0	49.0	73.0	58.8	55.0	78.7	107.2	55.5	63.5
1906	45.5	31.3	64.5	55.3	57.7	63.2	103.6	47.7	56.1	17.8	38.9	64.7	53.8
1907	76.4	108.2	60.7	52.6	42.9	40.4	49.7	54.3	85.0	65.4	61.5	47.3	62.0
1908	39.2	33.9	28.7	57.6	40.8	48.1	39.5	90.5	86.9	32.3	45.5	39.5	48.5
1909	56.7	46.6	66.3	32.3	36.0	22.6	35.8	23.1	38.8	58.4	55.8	54.2	43.9
1910	26.4	31.5	21.4	8.4	22.2	12.3	14.1	11.5	26.2	38.3	4.9	5.8	18.6
1911	3.4	9.0	7.8	16.5	9.0	2.2	3.5	4.0	4.0	2.6	4.2	2.2	5.7
1912	0.3	0.0	4.9	4.5	4.4	4.1	3.0	0.3	9.5	4.6	1.1	6.4	3.6

1913-1922

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1913	2.3	2.9	0.5	0.9	0.0	0.0	1.7	0.2	1.2	3.1	0.7	3.8	1.4
1914	2.8	2.6	3.1	17.3	5.2	11.4	5.4	7.7	12.7	8.2	16.4	22.3	9.6
1915	23.0	42.3	38.8	41.3	33.0	68.8	71.6	69.6	49.5	53.5	42.5	34.5	47.4
1916	45.3	55.4	67.0	71.8	74.5	67.7	53.5	35.2	45.1	50.7	65.6	53.0	57.1
1917	74.7	71.9	94.8	74.7	114.1	114.9	119.8	154.5	129.4	72.2	96.4	129.3	103.9
1918	96.0	65.3	72.2	80.5	76.7	59.4	107.6	101.7	79.9	85.0	83.4	59.2	80.6
1919	48.1	79.5	66.5	51.8	88.1	111.2	64.7	69.0	54.7	52.8	42.0	34.9	63.6
1920	51.1	53.9	70.2	14.8	33.3	38.7	27.5	19.2	36.3	49.6	27.2	29.9	37.6
1921	31.5	28.3	26.7	32.4	22.2	33.7	41.9	22.8	17.8	18.2	17.8	20.3	26.1
1922	11.8	26.4	54.7	11.0	8.0	5.8	10.9	6.5	4.7	6.2	7.4	17.5	14.2

1923-1932

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1923	4.5	1.5	3.3	6.1	3.2	9.1	3.5	0.5	13.2	11.6	10.0	2.8	5.8
1924	0.5	5.1	1.8	11.3	20.8	24.0	28.1	19.3	25.1	25.6	22.5	16.5	16.7
1925	5.5	23.2	18.0	31.7	42.8	47..	38.5	37.9	60.2	69.2	58.6	98.6	44.3
1926	71.8	70.0	62.5	38.5	64.3	73.5	52.3	61.6	60.8	71.5	60.5	79.4	63.9
1927	81.6	93.0	69.6	93.5	79.1	59.1	54.9	53.8	68.4	63.1	67.2	45.2	69.0
1928	83.5	73.5	85.4	80.6	76.9	91.4	98.0	83.8	89.7	61.4	50.3	59.0	77.8
1929	68.9	64.1	50.2	52.8	58.2	71.9	70.2	65.8	34.4	54.0	81.1	108.0	65.0
1930	65.3	49.2	35.0	38.2	36.8	28.8	21.9	24.9	32.1	34.4	35.6	25.8	35.7
1931	14.6	43.1	30.0	31.2	24.6	15.3	17.4	13.0	19.0	10.0	18.7	17.8	21.2
1932	12.1	10.6	11.2	11.2	17.9	22.2	9.6	6.8	4.0	8.9	8.2	11.0	11.1

Magnetism—The vortex nature of sunspots suggested the possibility of their being electromagnets; the analysis of the spectrum lines (Hale) revealed breaking up of the lines similar to that found by Zeeman when the source of light was placed between the jaws of an electromagnet. The strength of the magnetic field in sunspots was found to be about that of the most powerful laboratory electromagnets. The magnetic polarities of pairs of sunspots were found to be opposite. Investigations at Mount Wilson over several sunspot cycles have shown that for pairs of sunspots the advancing spot (in the sense of the solar rotation) is a north pole for the majority of pairs in either the north or south polar hemisphere, while the leading spot is a south pole in the other hemisphere. This arrangement reverses in the next sunspot cycle, with a further reversal in the following cycle. Thus there is a magnetic cycle of two eleven-year sunspot cycles, a fact of great importance in the problem of the causes of sunspots.

Convection—When the spectrum of a sunspot situated at some distance from the centre of the solar disc is observed with the slit of the spectroscope lying along the radius of the disc which passes through the middle of the spot, the spectrum lines are found to be displaced in opposite directions in the opposite sides of the penumbra indicating velocities of the solar gases to or from the axis of the sunspot (Evershed). The strong spectrum lines from high-level hydrogen and calcium indicate velocities inward of about 2 miles a second, other spectrum lines indicate little or no velocity, while the majority of the narrow spectrum lines indicate velocities of the gases of the various elements producing them outward from the axis of the spot and increasing with depth in the solar atmosphere. The measurement of the displacements of the lines of many elements yielded a table of relative elevations in the solar atmosphere of the various gases (St. John) comparable with the elevations determined by the earlier method of measuring the lengths of the arcs of the various spectrum lines in the "flash spectrum" taken at the time of a solar eclipse.

Temperature—The darker sunspots are obviously at lower temperature than the general surface of the sun. Spectrum lines which are widened in the furnace spectrum relatively to the hotter electric

arc spectrum, are also widened in the sunspot spectrum relatively to the general spectrum of the sun (King). Ultra-violet light from the umbra is of the order of one-tenth as strong as that from the general solar surface. Oxides and hydrides occur in the umbra.

Faculae, flocculi and prominences—The large bright areas or faculae usually associated with the sunspots and generally varying along with them throughout the progress of the eleven year cycle (Table II), are much more apparent when viewed in blue or violet light than, say, in yellow light. The early series of solar photographs made at Ottawa with the 15-inch equatorial telescope and enlarging lens, using isochromatic plates and yellow filter which together confined the light to the narrow range, λ5500-5700, showed little evidence of the faculae. The later series, employing the coelostat reflecting telescope and slow fine-grained plates sensitive to violet and blue light, show the faculae prominently especially near the solar limb, as seen in the reproduction of a photograph taken July 31, 1937 (Fig. 3). The reason for the improved contrast is mainly the high elevation of the faculae above much of the scattering and absorption of the lower atmosphere of the sun which is great for violet light and much greater for the ultra-violet. This is evident also in the greater weakening of the solar limb relatively to the centre of the solar disc, the limb being one-third or less as bright as the centre for wave-length 3200 in the ultra-violet, while at 5600 it is more than half as bright (Abbot).

The faculae and general flocculation of the sun are seen in greater contrast when the photograph is confined to either of the bright violet radiations of calcium, H_2 or K_2. A series of such spectroheliograms (Mount Wilson scale plates of calcium flocculi) exhibiting the range of calcium flocculation at different stages of the sunspot cycle is shown in Fig. 4, a reduced reproduction from a report[5] by Brunner, from Zürich observatory.

Both the calcium and the bright and dark hydrogen flocculi, the latter observed in the red radiation, H , are now recorded systematically at several observatories. It was found that the dark hydrogen flocculi were in reality the prominences seen in projection

[5]W. Brunner, *Character Figures of Solar Phenomena*, 1923-1928, Vol. I, 1932. (Int. Astron. Union).

on the solar disc, such prominences or protuberances as were first seen on the solar limb at times of solar eclipse. They are regularly observed at the limb by spectroscopic methods. While these outbursts are frequently associated with spotted regions they also occur farther north and south than the zones of sunspots. Some outbursts have been observed departing from the sun with increasing velocity (Pettit), thus contributing matter to interplanetary space. Such material would vary throughout the sunspot cycle. The prominences exhibit many interesting forms and varying radial and tangential velocities. Some very successful motion pictures of them have been recorded at the McMath-Hulbert observatory. One of the records indicates a velocity of more than 450 miles per second, greater by 70 miles per hour than the velocity necessary for escape from the surface of the sun. One of the most curious forms is that of a prominence of July 29-31, 1913, observed at Kodaikanal[6] and Zô-Sè observatories. It appeared as a curved arm on July 29 and as an inverted U or horseshoe on July 30 and 31, disappearing on August 1. It evidently was an inverted U-shaped vortex. It appeared over a large sunspot.

The emission of ultra-violet light as an important variable—While the sunspots themselves emit less radiation that the same area of the general solar surface, the larger bright high-level areas of the faculae would more than compensate for this (Fig. 1). Measurements of the intensity of the solar radiation indicate that it is greater at sunspot maximum than at minimum. A relatively large part of such increase must be attributed to the ultra-violet radiation. This large variation in the ultra-violet emitted by the sun during the course of the sunspot cycle would produce great variations in the ionization of the gases of the terrestrial atmosphere, especially at the low pressures of the upper atmosphere. The variable host of fleet electrons thus liberated in the atmosphere would by their systematic motions produce electromagnetic variations, and would produce variable numbers of cloud nuclei down through the atmosphere resulting in varying haziness and cloudiness with consequent serious meteorological variations. This obvious factor was suggested twenty-five years ago to account for sunspot influences, discussed frequently at meetings of

[6]Mrs. M. A. Evershed, *Monthly Notices*, 73, 429, 1913.

this Society since then, as well as in articles and radio broadcasts. Some ten years ago it was resuggested and rejuvenated by others, and it is now generally regarded as an important if not the most important factor of the solar variations in bringing about variations in the solar system.

Our concern is now with the extent of the cyclical variations accompanying the eleven-year fluctuations in the solar phenomena.

Sunspots and Associated Physical Phenomena

Before considering terrestrial changes associated with the sunspot cycle, some phenomena of the solar system showing relationship to the solar variations will be mentioned.

Variations in the shape of the solar corona—Considerable variety in the form of the solar corona is exhibited during different eclipses. Streamers extending about 10 million miles from the sun have been observed, but the usual photographic records show streamers of from one to three diameters of the sun in length. They are usually observed in association with prominences on or near the solar limb. At times the corona takes the form of a band about a solar radius in width extending two or more solar diameters from both equatorial limbs; while at other times the equatorial streamers are not so long and others extend from the northerly and southerly limbs in a more or less irregular star-shape. Forty years ago Hansky assembled drawings of the coronae observed from 1860 to 1896, pointing out that the former equatorial type of corona occurred near sunspot minimum and the latter star-shaped type at or near sunspot maximum[7]. Inspection of the drawings indicates that the form is related to the solar disturbances at the time as judged from the sunspot number of the month in which the eclipse took place. Thus, the corona of August 29, 1867, was of the minimum type, while 2.5 years after sunspot minimum the corona of August 7, 1869, was of the maximum type, the respective sunspot numbers for the months of occurrence being 4.9 and 79.6. Similarly maximum types were observed at the eclipses of 1860, 1870, 1871, 1883 and 1893, the sunspot numbers for the months being respectively, 100, 130, 90, 77 and

[7]Reviewed in Observatory, vol. 21, p. 102, 1898.

88. Minimum types were seen at the eclipses of 1878 and 1889, the monthly numbers being 0.1 and 0.8. Hansky predicted a minimum type for May 28, 1900, and the corona actually observed was mainly of the minimum type but with an errant streamer suggestive of the maximum type; the sunspot number was 15.2, more than a year before sunspot minimum.

Fairly rapid changes occur in the quantity and distribution of the coronal matter, as well as the general waxing and waning with the sunspot cycle. Such variations affect the amount of radiation transmitted, and especially the ultra-violet radiation, which is more scattered by the coronal particles.

The light of the corona is a blend of reflected and scattered sunlight with emission characteristic of the corona, a prominent radiation being in the green at λ5303.

Variations in the brightness of comets—Ultra-violet light liberates electrons from the material of comets just as it does in the upper atmosphere of the earth, the electrons in turn crash through the gaseous material in the heads and repulsed tails of comets producing the light characteristic of the gases present. It follows therefore that periodic comets on their successive returns about the sun will vary in brightness with the phase of the sunspot cycle at the time, since as has been shown the ultra-violet light emitted by the sun must vary in great degree, during the progress of the sunspot cycle. The variations in the returns to perihelion of Encke's comet (period, 3.3 years), have been shown[8] by Bosler to follow the progress of the sunspot cycles remarkably well from 1786 to 1908. Using the table of magnitudes corrected for the inverse squares of the distances of comet from sun, and earth from comet, a smoothed mean eleven-year cycle shows fair agreement especially in the first 8 years of the cycle with the smoothed mean cycle of sunspot numbers for the months of observation of the comet, thus:

Year:	0	1	2	3	4	5	6	7	8	9	10	11
Mag.:	7.0	7.5	7.2	6.3	5.7	5.9	6.3	6.6	6.4	6.2	6.2	6.3
No.:	12	29	46	62	78	79	63	45	34	25	13	8

If the 31 observations of the magnitude of Encke's comet and the sunspot numbers of the corresponding months be grouped into

[8] J. Bosler, Comptes Rendus, vol. 148, pp. 1738-1741, 1909.

two nearly equal groups, the first comprising all observations made in years of sunspot minimum and within two years of a minimum, and the other group consisting of the remaining observations, the following means result:

Group 1, Magnitude, 6.54 ±.19; sunspot number, 28.1.
Group 2, " 5.55 ±.10; " " 62.2.

In the latter group the record of 1885 is omitted, the magnitude of 9.7 being the one very discordant observation, all the others of the group falling between 5.0 and 6.4. Thus, it appears that in the mean there is a difference of about one magnitude, or an increase in brightness of 2.5 times for an increase in sunspot number from 28 to 62.

If Encke's comet is thus sensitive to the spottedness of the Sun, or to the emission of ultra-violet light, it is not unreasonable to suggest that the disappointingly weak apparition of Halley's comet in the late spring and early summer of 1910 was due in part at least to the small number of solar spots of all kinds at that time. Similarly, it is reasonable to suppose that the great brightness of this comet in 1066 was due to a state of great disturbance on the sun at that time. The Chinese records referred to throw some light on the question. The six records in 1077-8-9 and the three in 1120-2, assuming that they were all near times of maximum, like those from 1616 to 1638, would be in harmony with the idea that a maximum was near 1077 and another near 1122, and consequently the year 1066 would be also near a sunspot maximum. (The widths of the annual growth-rings of the California redwoods, to be referred to later, add supporting evidence that 1066 was near a sunspot maximum.)

Variations in the polar caps of Mars—An apparent relationship between the sunspot cycle and the positive and negative departures from normal in the size of the polar caps of Mars, from 1862 to 1913, was shown[9] by Antoniadi. The positive departures were associated with small spottedness of the sun and the negative with greater spottedness; or, the rate of "melting" of the polar caps was greater at maximum than at minimum of sunspots. Extracting the data from the charts the following means were derived for 8 measurements at minimum and within 2 years before and after minimum and for the

[9]E. M. Antoniadi, Monthly Notices, vol. 76, pp. 643-645, 1916.

remaining 12 measurements of the departures from normal, together with the associated mean sunspot numbers:

Near sunspot minima		*Near sunspot maxima*	
Sunspot Number	Polar Cap Departure	Sunspot Number	Polar Cap Departure
8	+4°.3	58	−3°.2

Smoothed mean cycles of the sunspot numbers for the years of the observations of the polar caps, and of the negative departures in degrees from the greatest (at minima) are as follows:

Year:	0	1	2	3	4	5	6	7	8	9	10	11
Spots:	7	11	30	66	90	79	58	41	31	21	11	8
Caps:	0	5.1	9.9	11.9	12.4	11.9	11.7	11.7	9.7	6.6	4.3	0.7

The sunspot cycle thus appears to exert an influence on the Martian meteorology. The colour variations in Jupiter show certain unique coincidences with the minima and maxima of sunspots; but the period of the variations appears to be more than 12 years[10]. And so consideration now turns to the physical influences of the sunspot cycle on the earth.

Many investigators have contributed innumerable treatises dealing with the influence of sunspots on such terrestrial variables as, the aurora, magnetism, temperature, precipitation, haziness and cloudiness, violent storms and their drift in latitude from the equator, evaporation, and lake levels. Only brief mention can be made of the well established influence of the sunspot cycle in electromagnetic variations, and of some results derived at the Dominion Observatory, much of which concerns phenomena in Canada investigated in collaboration with Mr. John L. O'Connor chiefly as a contribution to the conference on cycles called in August, 1931, by Mr. Copley Amory at his summer place, Matamek River, Quebec.

Aurora polaris—The variation in the displays of the northern lights from year to year was of course an early observation. In olden days great auroral apparitions were regarded as portents of calamitous happenings on the earth. Possibly storminess was frequently observed to follow in their wake. Records finally showed a periodicity in their waxing and waning, and about 90 years ago a

[10]Stanley Williams, Monthly Notices, vol. 59, pp. 376-384, 1899.

relationship to the sunspot variations was suggested (Sabine). The Swedish records were shown by Rubenson to support this idea; and later discussion of the records by Ellis established the same average period as that of the sunspot fluctuations, but appeared to indicate for the period 1729 to 1771, that the minima and maxima of the aurorae lagged on the average about a year after those of the sunspots[11]. Error of observations or a systematic change in cloudiness throughout the cycle might be suspected as affecting this apparent lag; but a similar lag after sunspot maximum has been noted in the magnetic cycle, reasonably explained by Cortie as due to the latitude drift of the solar spots towards the equator which places the spots after maximum nearer the radius vector of the earth than those occurring at maximum, thus improving their directional action. The smoothed mean eleven-year cycle of auroral numbers charted in the paper previously mentioned[1] shows the lag at maximum relatively to the sunspot cycle, for the years, 1784 to 1869. This with the other material for the period is copied in Table IV for further reference.

TABLE IV.—Mean Sunspot Cycle and Smoothed Mean Cycles in Various Phenomena 1784-1869.

Year....	0	1	2	3	4	5	6	7	8	9	10	11
Mean Cycle, Sunspot Relative Numbers	6	18	46	70	86	84	86	58	44	31	21	10
Smoothed Mean Cycle, Auroral Frequency	58	61	68	74	81	92	99	92	79	69	59	51
Smoothed Mean Cycle, Mar. + Apr. Rainfall in mm., Montdidier, France	64	65	76	84	86	88	83	78	77	67	62	65
Smoothed Mean Cycle, Apr. Dates of Bird Arrivals, Montdidier, France	13.4	13.7	13.6	14.5	17.2	17.8	16.4	14.3	14.0	14.4	13.7	13.7
Smoothed Mean Cycle, Annual Ring in mm., California Redwoods	.840	.853	.873	.903	.915	.910	.898	.878	.860	.865	.870	.838
Smoothed Mean Cycle, Commodity Prices Gt. Britain and Ireland	163	158	158	157	154	150	149	154	157	158	167	171

Now, while it is established that the variations in aurorae synchronize with the solar variations, what is their cause? An early theory was based on the assumption of a variable flux of electricity from the sun to the earth. A second assumes that the disturbed areas on the sun emit X-rays. These are assumptions. The Ottawa explanation is based on the facts that ultra-violet light ionizes gases,

[11]William Ellis, Monthly Notices, vol. 64, pp. 228-236, 1904.

especially at low pressure and that the high-level disturbed areas in the solar atmosphere emit more ultra-violet light than the undisturbed surface of the sun. It is convenient to quote from an article on the Northern Lights prepared in February, 1926, for radio broadcast,—rather fully since it deals also with the induction of accompanying meteorological phenomena:

"Not very long ago it was supposed by some that the polar light was sunlight reflected from icebergs. However, apart from other objections to this supposition, when the light was examined through a prism it was found that it did not resemble sunlight but was similar to the light emitted by certain gases of the atmosphere, oxygen, nitrogen, helium and hydrogen, when conducting electricity in tubes at very low pressures. And so it is believed that the polar lights are produced by electricity passing through the gases at the very low pressures of the upper atmosphere. . . . But whence come the electrons whose collisions with the atoms of the gases in the upper atmosphere cause them to emit light? One certain source is to be found in the action of ultra-violet light which is known to liberate electrons from gases at low pressures. . . . There is a theory . . . that the sun acting like the hot filament of a radio tube emits electrons which travel through the vacuum of inter-planetary space and encounter the earth which acts like the plate of the tube. Carrying the analogy farther, a planet or swarm of meteors coming between the sun and an outer planet would act like a grid interfering with the flow of radiation from the sun to the planet, and possibly make an appreciable effect on its electromagnetic state. Such an effect was actually found by a party of the Dominion Observatory, Ottawa, during the eclipse of January 24, 1925. . . . Whether the electrons arrive at the earth directly from the sun, or are liberated in the rare atmosphere by the high frequency radiations from the sun, the electrons would flow from the daylight side of the earth into the night side where the electrons are not being directly produced, and auroral light would be emitted as a result of their flow through the gases at low pressure. The auroral discharge can always be detected in the clear night sky by spectroscopic methods, but not always are the displays evident to the eye. . . . Now the increased number of electrons in the atmosphere, as evidenced by the increase in the number of auroral discharges, would increase the number of nuclei of cloud particles, and hence cloudiness and rainfall would be increased. Thus living things would be affected. Sicknesses due to microbe action would be increased. Certain epidemics have been quite seriously associated with the variations in the aurora. Possibly there is something more than poetic fancy and superstition in the lines of Aytoun: 'Fearful lights that never beacon, Save when kings or heroes die'. . . . However, it does appear that auroral discharges may be a step in the mechanism of our meteorological variations. They may be quite closely associated with the continued formation of compounds of nitrogen

with oxygen and hydrogen,—compounds so vital to the needs of vegetation. . . . And now we are beginning to consider the aurora as a serious menace to radio reception. Reflect that the four years of our popular radio development were four years of minimum of spots on the sun and of auroral displays, the minimum year being in 1923. Sunspots and northern lights are now increasing and we have gone through a spell of abnormally bad radio reception. Are we to have even poorer reception as the spots and northern lights increase to a maximum in 1928?"

The expected happened to radio reception at the maximum of sunspots in 1928; just as telegraphic transmission by wire has frequently been affected when sunspots were numerous. However, the prediction made at a meeting of radio engineers and dealers was not received with enthusiasm!

Magnetism—The variations in the measurements of the daily range in horizontal direction and force of terrestrial magnetism fluctuate with great precision with the solar variations. The work of Ellis[12] and many others established the relationship beyond doubt. Arguments were levelled against the possibility of such a relationship on the ground that the energy changes in the solar disturbances were insufficient to produce the changes on the earth, and the notion was considered that the solar system encountered waves of material in its journey through space which produced effects on the earth and the sun simultaneously. However, the coincidence of localized disturbances on the sun and severe magnetic storms on the earth establishes a direct relationship. The rotation of the earth, its yearly motion around the sun, ultra-violet light and its variations would seem to account for the changes in terrestrial magnetism; pulsations in the motion of the earth in the journey through space would introduce steady magnetic fluctuations in yearly and lunar periods.

In Table V are given for the two cycles, 1878 to 1900, the yearly means of the monthly sunspot relative numbers along with the yearly means of the Diurnal Ranges in magnetic Horizontal Force and Declination, the latter derived from the charts of the Greenwich observations[13], which show many coincidences in the minor magnetic and solar changes. From the means of the two cycles it will be seen that 1 minute of arc in declination and .0003 C.G.S. in horizontal force correspond to a change of 22 in the sunspot number.

[12]William Ellis, Monthly Notices, vol. 60, pp. 142-157, 1899.

[13]Astronomer Royal, Monthly Notices, vol. 63, p. 462, 1903.

TABLE V.—Sunspot Cycles 1878-1888 and 1889-1900, and Associated Cycles of Mean Diurnal Ranges in Magnetic Declination in Minutes of Arc, and Magnetic Horizontal Force in 10^{-5} C.G.S.

Year	0	1	2	3	4	5	6	7	8	9	10	11
						Sunspot Relative Numbers						
1878....	3	6	32	54	60	64	64	52	25	13	7	
1889....	6	7	36	73	85	78	64	42	26	27	12	10
Mean...	5	7	34	64	72	71	64	47	26	20	10	10
						Diurnal Range in Magnetic Declination						
1878....	6.8	6.9	8.0	9.1	8.9	9.3	9.6	9.0	8.3	7.7	7.2	
1889....	6.8	7.3	8.6	9.6	10.3	9.6	9.6	8.5	7.4	7.3	7.0	6.6
Mean...	6.8	7.1	8.3	9.4	9.6	9.5	9.6	8.8	7.8	7.5	7.1	6.6
						Diurnal Range in Magnetic Horizontal Force						
1878....	113	128	161	186	197	210	192	182	171	156	151	
1889....	136	140	181	217	224	223	204	182	156	150	147	131
Mean...	120	134	171	202	211	217	198	182	164	153	149	131

Temperature—It has long been known that temperatures are on the average higher at sunspot minimum than at maximum. A survey of the Canadian meteorological records reveals this fact beyond any doubt, a range of 1°.5 being a conservative estimate of the average effect in the sunspot cycle for the populated belt across Canada. Some of the prairie stations exhibit ranges as high as 4° F. in the mean sunspot cycle, and double this amount for certain months. However, since the records cover a short span of years, the process of smoothing has been adopted, the formula used being, 0.25 (a+2b+c), where b is the mean value for the year of the cycle in question and a and c the values for the year before and the year after. This naturally reduces the range. As there has been a misunderstanding[14] as to the method by which these high ranges have been found, an example using the Edmonton records of temperature, 1883-1925, will be given:

Year	0	1	2	3	4	5	6	7	8	9	10	11	Range F.°
1878.	—	—	—	—	—	32.9	33.5	36.6	34.5	31.5	34.7	—	—
1889.	40.9	36.6	38.4	36.3	34.6	36.7	37.0	34.8	36.7	38.2	34.6	37.7	—
1901.	39.0	36.6	37.6	36.2	39.4	40.1	35.2	—	33.8	38.4	36.0	39.5	—
1913.	37.8	37.5	39.2	34.8	34.6	37.9	35.5	35.9	37.1	36.7	—	—	—
1923.	38.7	36.4	35.9	—	—	—	—	—	—	—	—	—	—
Mean	39.1	36.9	37.8	35.8	36.2	36.9	35.3	35.8	35.5	36.2	35.1	38.6	3.8
Smoothed	38.4	37.7	37.1	36.4	36.3	36.3	35.8	35.6	35.8	35.8	36.3	37.9	2.8
						Mean Cycles, January, February and March							
Jan..	10.6	6.0	12.1	3.5	7.5	4.1	4.0	3.8	− 0.6	8.3	− 1.7	11.7	—
Feb..	16.2	11.6	10.7	5.9	7.6	12.8	7.9	17.0	13.5	1.0	9.3	14.6	—
Mar..	27.8	24.5	23.8	20.4	25.2	24.9	20.9	22.3	19.7	25.8	17.9	21.8	—
Mean	18.2	14.0	15.5	9.9	13.4	13.9	10.9	14.4	10.9	11.7	8.5	16.0	4.0
Smoothed	16.6	15.5	13.8	12.2	12.7	13.1	12.5	12.6	12.2	10.7	10.9	14.7	3.0

[14] Andrew Thomson, Journal R.A.S.C., vol. 30, p. 215, 1936.

The ranges given for the mean cycles of the first three months of the year, 4°.0 and 3°.0, were derived by taking the difference between the means of the values for years 0, 1 and 11, and the means for the years about sunspot maxima, years 3, 4, 5 and 6. They are of course smaller than the ranges shown in the cycles.

TABLE VI.—Temperatures in Canada, Smoothed Mean Eleven Year Cycles.

Year 0	1	2	3	4	5	6	7	8	9	10	11	Range F.°
St. John's, Newfoundland, 1872-1920												
41.4	40.9	40.4	40.5	40.4	40.2	40.3	40.4	40.6	40.7	40.4	40.8	1.2
Charlottetown, Prince Edward Island, 1873-1925												
42.4	42.0	41.4	41.0	40.7	40.8	41.0	41.2	41.4	41.7	42.0	42.4	1.7
Halifax, Nova Scotia, 1874-1928												
44.1	43.3	43.3	43.0	42.8	43.2	43.4	43.4	43.7	43.7	43.8	44.3	1.5
Southwest Point, Anticosti, 1882-1920												
35.4	34.8	34.3	34.4	34.2	34.0	34.3	35.0	35.7	35.7	35.1	35.1	1.4
Montreal, Quebec, 1873-1925												
42.8	42.6	42.7	42.2	41.5	41.9	42.2	42.0	42.1	42.5	42.7	42.8	1.3
Toronto, Ontario, 1873-1925												
46.0	45.7	45.5	45.0	44.7	44.8	44.7	44.7	45.2	45.6	45.8	46.1	1.4
Winnipeg, Manitoba, 1873-1925												
36.7	35.8	34.9	34.1	33.9	34.2	34.2	34.4	34.6	34.6	35.2	36.3	2.8
Prince Albert, Saskatchewan, 1885-1925												
33.6	33.3	32.7	32.0	32.2	33.0	32.8	32.3	32.2	32.1	32.0	32.9	1.6
Edmonton, Alberta, 1883-1925												
38.4	37.7	37.1	36.4	36.3	36.3	35.8	35.6	35.8	35.8	36.3	37.9	2.8
Calgary, Alberta, 1884-1925												
39.5	39.1	38.6	37.9	38.1	38.6	38.3	38.1	37.9	37.3	37.1	38.5	1.6
Kamloops, British Columbia, 1891-1925												
47.3	47.8	47.5	46.8	47.2	47.9	47.1	46.7	46.8	46.6	46.4	46.8	1.1
Barkerville, British Columbia, 1888-1925												
36.1	35.9	35.6	34.8	35.0	35.6	34.9	34.2	34.6	35.1	35.5	36.1	1.9
Victoria, British Columbia, 1891-1925												
50.1	50.0	50.0	49.5	49.2	49.3	49.3	49.2	49.1	49.1	49.4	50.0	1.0
Mean												
41.1	40.7	40.3	39.8	39.7	40.1	39.9	39.7	40.0	40.0	40.1	40.7	1.4
Year 0	1	2	3	4	5	6	7	8	9	10	11	—

From the Winnipeg records of temperature were derived the following two sets of monthly means for 15 years each, the first for the years of minima, one year after and one year before from 1877 to 1924, and the second for the years of maxima, one year before and one year after from 1882 to 1929:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Min..	−1.6	2.1	16.6	39.6	52.3	62.8	67.6	64.0	54.1	42.7	28.0	8.3	36.4
Max..	−4.6	−0.2	16.0	36.6	50.2	61.7	65.9	64.2	54.3	40.8	22.8	3.2	34.2
Diff..	3.0	2.3	.6	3.0	2.1	1.1	1.7	−.2	−.2	1.9	5.2	5.1	2.2

Thus it appears that for the three years about sunspot minima temperatures are higher systematically, with two small exceptions, than for the three years about sunspot maxima, the mean value of the difference being 2°.2 F. The differences for November and December are exceptionally large.

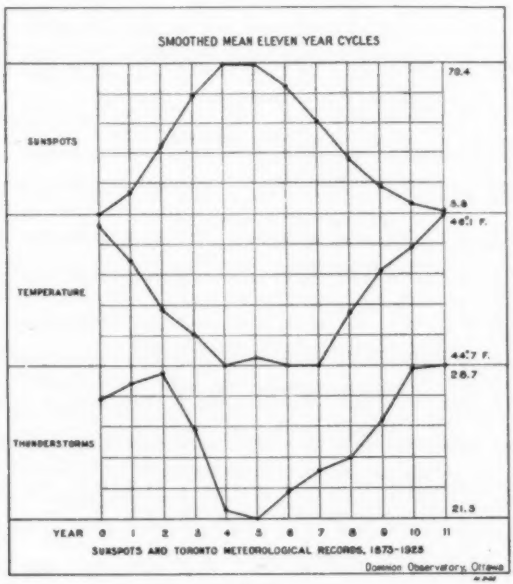


Fig. 5

In Table VI are given smoothed mean eleven year cycles in temperature for 13 stations in Canada. The years are for sunspot minima, 1 year after, 2 years after, and so on. The mean cycle for these stations shows the progressive influence of the sunspot cycle, the excess at minimum over maximum being 1°.4 F.

In Fig. 5 is charted the mean temperature cycle in comparison with the mean sunspot cycle, both smoothed. In Fig. 7 the cycle for

the three prairie stations, Prince Albert, Edmonton and Calgary, is charted in comparison with the sunspot cycle covering the period of the temperature records.

The lower temperatures at maximum of sunspots, despite the greater amount of radiation from the sun at maximum, are ascribable to the greater opacity and cloudiness of the atmosphere induced by the greater ionization by ultra-violet light at sunspot maximum.

TABLE VII.—Precipitation, Smoothed Mean Eleven Year Cycles (inches).

Year 0	1	2	3	4	5	6	7	8	9	10	11	Range %
OCEANIC TYPE (AQUENE)												
Darwin, Australia, 1870-1924												
57.0	59.6	62.2	63.6	63.9	61.7	63.0	64.3	63.8	63.7	59.4	56.4	14
Auckland, New Zealand, 1853-1923												
42.7	43.4	44.8	46.2	48.3	47.1	43.5	41.6	41.8	42.6	42.8	43.0	13
Batavia, East Indies, 1864-1923												
67.6	66.0	70.0	75.9	79.2	77.8	74.4	71.7	70.5	71.3	71.3	70.3	20
Madras, India, 1813-1920												
43.8	46.6	49.3	51.1	52.6	52.1	50.8	51.9	50.7	48.6	48.1	45.1	20
St. John's, Newfoundland, 1874-1920												
49.2	48.8	51.4	55.5	57.6	57.6	57.8	55.8	54.7	55.5	55.3	52.8	18
Victoria, British Columbia, 1891-1925												
26.4	26.9	28.2	29.9	31.1	29.3	27.7	29.9	31.4	30.0	28.8	27.5	18
INLAND TYPE (TERRENE)												
Montreal, Quebec, 1874-1925												
44.6	41.1	38.9	38.9	39.5	39.5	40.3	40.3	39.4	39.6	42.0	45.2	16
Toronto, Ontario, 1874-1925												
33.1	33.2	33.0	32.3	32.2	31.7	30.1	29.9	30.9	30.5	29.5	31.2	10
Prince Albert, Saskatchewan, 1885-1925												
17.0	15.6	15.0	14.8	13.9	13.5	15.0	16.8	16.6	16.0	18.3	19.1	41
Qu'Appelle, Saskatchewan, 1884-1935												
19.6	19.7	19.8	20.6	19.5	16.6	15.8	16.7	17.7	18.6	18.6	18.6	30
Regina, Saskatchewan, 1896-1936												
14.8	14.8	15.3	16.7	16.1	13.9	13.1	13.9	14.7	15.5	15.8	14.8	27
Swift Current, Saskatchewan, 1895-1936												
15.3	15.3	15.4	16.2	15.8	14.6	13.3	13.4	15.2	16.8	16.3	15.3	26
Edmonton, Alberta, 1883-1925												
20.5	20.1	19.7	18.4	16.8	15.9	16.2	15.4	13.8	14.9	19.5	21.7	57
Calgary, Alberta, 1885-1924												
20.0	20.5	17.2	13.0	12.0	12.8	14.0	14.8	14.3	15.4	18.7	19.7	71
Kamloops, British Columbia, 1895-1925												
10.7	11.1	11.2	10.4	10.3	10.0	9.0	8.9	9.3	9.2	10.2	10.9	26
Mean												
21.7	21.3	20.9	20.1	19.6	18.7	18.5	18.9	19.1	19.5	21.0	21.8	18
Year 0	1	2	3	4	5	6	7	8	9	10	11	—

Thunderstorms—The occurrence of thunderstorms is associated with the warmer days of the month and the warmest months of the year. For the ten years of the sunspot cycle 1913-1922, the six following stations situated in the northerly part of the province of Ontario, near the forested regions, had an average number of 13.7 thunderstorms per year for each station, and the monthly averages were as follows for Ottawa, Parry Sound, Haileybury, Cochrane, White River and Port Arthur:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.0	0.1	0.4	0.5	0.9	2.3	4.1	3.0	1.8	0.7	0.1	0.0

Thus, during the hottest months of the year, July and August, 51 per cent of the thunderstorms occurred; while from June to September 80 per cent of the storms took place. One might therefore expect that more thunderstorms would occur during the warmer years of the sunspot cycle, namely the years of fewer sunspots, when more intensely hot days are usually experienced.

In Fig. 5, the smoothed mean cycle for thunderstorms recorded at Toronto, from 1876 to 1922, is charted. It is seen to be inverse to the sunspot cycle like the temperature cycle. The numbers are as follows, those of four of the years not being available:

Year	0	1	2	3	4	5	6	7	8	9	10	11
1867.....	—	—	—	—	—	—	—	—	—	19	33	—
1878.....	30	37	47	24	28	5	30	19	26	22	23	—
1889.....	24	21	—	—	—	—	23	30	19	34	27	34
1901.....	25	26	19	26	15	21	—	27	21	21	34	26
1913.....	22	27	26	24	27	31	21	16	32	32	—	—
Mean....	25.3	27.8	30.6	24.5	23.3	19.0	24.5	23.0	24.5	25.6	29.3	30.0
Smoothed	27.1	27.9	28.4	25.7	22.0	21.5	22.8	23.8	24.4	26.3	28.6	28.7

There is thus a range of 33 per cent in the smoothed mean cycle, the greater number occurring about the years of minimum of sunspots. The records are presumed to be homogeneous.

The following mean and smoothed mean cycles in provincial records of thunderstorms support the evidence of the Toronto records in indicating that the sunspot cycle has a serious influence on the occurrences of thunderstorms:

Year 0	1	2	3	4	5	6	7	8	9	10	11	Range %
Ontario Thunderstorms, 10 Stations, 1901-1912												
Mean 22.1	25.3	19.4	20.6	16.8	21.2	17.6	17.5	16.0	19.9	21.2	21.0	—
Smoothed 22.6	23.0	21.2	19.4	18.9	19.2	18.5	16.9	16.9	19.3	20.8	21.3	36

Year 0	1	2	3	4	5	6	7	8	9	10	11	Range %
Manitoba Thunderstorms, 2 and 3 Stations, 1901-1912, 1913-1922												
Mean												
16.2	17.6	14.0	17.2	16.0	12.8	16.2	11.8	19.0	15.6	14.0	21.5	—
Smoothed												
17.9	16.4	15.7	16.1	15.5	14.5	14.3	14.7	16.4	16.1	16.3	18.3	28
Canada Thunderstorms, 1901-1912, 25 Stations: Alberta, 4; Saskatchewan, 4; Manitoba, 2; Ontario, 10; Quebec, 5.												
Mean												
16.8	17.3	13.8	15.2	14.3	14.7	14.0	12.8	13.7	14.8	16.1	14.7	—
Smoothed												
16.4	16.3	15.0	14.6	14.6	14.4	13.9	13.4	13.7	14.8	15.4	15.6	22

Forest fires are frequently started by lightning.[15] The chances for such fires are greater about the years of sunspot minima, not only

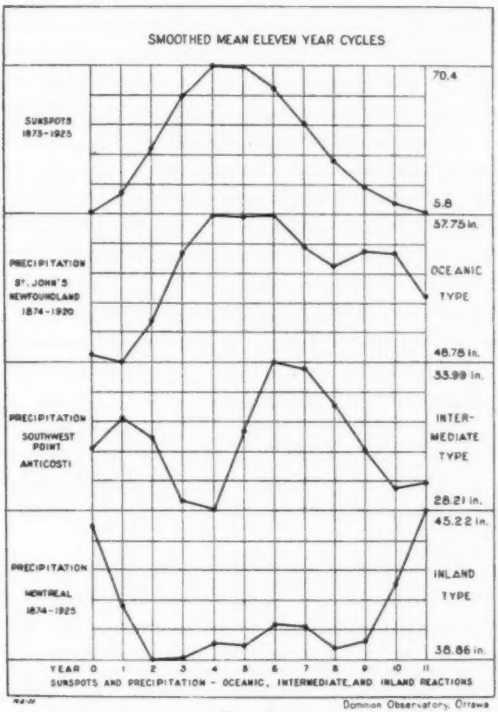


Fig. 6

[15]"Sunspots and Forest Fires", Forest and Outdoors, May, 1932.

due to the increased number of lightning flashes at such times, but also due to the higher temperatures at sunspot minimum and more transparent atmosphere with resultant greater rate of evaporation from the forest floor.[16] Thunderstorms could easily be automatically recorded by using a simple radio receiving device, and such a recorder should be installed in each province as an aid in fighting forest fires.

Precipitation—Investigation of the sunspot influence on precipitation has led us to what is considered to be a fundamental concept, namely, that there are two ideal responses to the sunspot cycle, the one an oceanic or *aquene* response, the other an inland or *terrene* response, the former in direct phase with the sunspot cycle and the latter in inverse phase.[15, 17, 18] Many regions show what may be termed an intermediate type of response, or to be consistent a *terraquene* response, in which the two ideals are blended in various ways. In Table VII are given some approximate oceanic and inland types. Among the intermediate types two pulses are frequently found, or virtually the half-sunspot cycle type, as has been found by others. Still another type is that exhibited by the Halifax records in which the mean sunspot cycle shows very little variation in the *yearly* precipitation; yet in which the records for six months resemble the oceanic type and the other six months the inland type. In such cases the records of precipitation should be considered by months, or better in association with winds off the ocean and winds off the land.

Types of precipitation cycles are charted in Fig. 6, (and also in Figs. 8 and 9 to be referred to later). A comparison of the St. John's, Southwest Point, Father Point and Montreal smoothed mean cycles shows the gradual waning of the oceanic effect with distance up the St. Lawrence River, little of the oceanic influence remaining in the Montreal cycle.

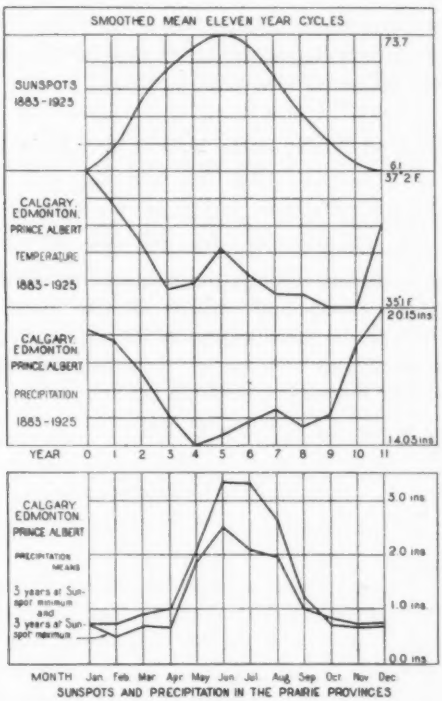
In Fig. 7 are charted the mean temperature and precipitation cycles for three prairie stations; and also monthly distribution of precipitation for sunspot minimum and sunspot maximum years and one

[16]"Sunspots and Forest Life", Forest and Outdoors, June, 1931.

[17]The writer and John L. O'Connor, "Sunspots and Co-Variants", The Institute Bulletin (Civ. Service, Ottawa), 10, 7, 1931.

[18]The same writers, "Sunspots and the Forest", Pulp and Paper of Canada, 36, 323, 1935; and Woodlands Review, June, 1935.

year before and after each. The gain in precipitation at sunspot minimum over maximum is quite appreciable in the summer months, when most of the precipitation occurs. At St. John's, Newfoundland, the opposite is the case, the greater precipitation coming in the fall and winter months.



SUNSPOTS AND PRECIPITATION IN THE PRAIRIE PROVINCES

Fig. 7

Such variations with the sunspot cycle, in temperature and precipitation must be accompanied by, or must cause, numerous physical variations on the earth, in such as, erosion and deposition of silt, rate of motion of glacier front, iceberg movements, lake levels, stream flow, seismic and volcanic action, violent storms, visibility and cloudi-

ness, and so on. Investigators have examined many of these phenomena. A few such have been inspected at the Dominion Observatory. The records of the levels of Lake Erie, 1788-1854, indicated[19] the influence of the sunspot cycle. The following mean and smoothed mean cycles indicate small influences of the sunspot cycle in precipitation in the Mohawk River Basin (State of New York Report on the Barge Canal, 1901, p. 790), and in the discharge of the Niagara River (Final Report of the Special International Board on Preservation of Niagara Falls, 1930, p. 326):

Year	0	1	2	3	4	5	6	7	8	9	10	11
Precipitation per Station, Inches, Mohawk River Basin, 1826-1899.												
Mean....	41.6	42.4	39.7	39.8	41.4	39.5	37.5	42.5	39.9	42.5	40.1	40.6
Smoothed	41.5	41.5	40.4	40.2	40.5	39.5	39.3	40.6	41.2	41.3	40.8	40.7
Niagara River Discharge, in 1000 cu. ft. per sec., 1860-1926.												
Mean....	203	201	197	202	214	207	211	209	206	208	200	196
Smoothed	201	200	199	204	209	210	209	209	207	206	202	199

The solar variations through the influence of the accompanying meteorological variations, and perhaps directly, must surely exert a profound effect on the various forms of life, and in consequence also on economic conditions. Some of these organic and economic fluctuations will be considered briefly in the light of the sunspot cycle.

[19]Pub. Am. Astron. Soc., vol. 4, p. 87, 1919.

(To be concluded.)

MINUTES OF THE ANNUAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The annual meeting of the Royal Astronomical Society of Canada was held in the Physics Building of the University of Toronto on Tuesday January 18, 1938, at 8 p.m. Dr. W. Findlay presided.

The minutes of the last annual meeting were taken as read.

The Secretary read his report which was received and adopted.

It was moved by Mr. Horning, seconded by Mr. Duncan that the Society's appreciation for the work of Professor Chant, the Editor of our publications, and also of Professor F. S. Hogg, the assistant editor, and of the members of the staff of the Dunlap Observatory be recorded.

The Treasurer, Mr. J. H. Horning, then presented an audited statement of the finances; this report will be found on another page.

Moved by Mr. Collins, seconded by Mr. E. J. A. Kennedy that a recommendation be passed on to the General Council to have $500.00 in the current account transferred to the Building Fund account. Carried.

Then followed the report of the Curator, which was approved.

Reports from a number of the Centres were received, with several yet to arrive. After scrutineers had been selected the ballots were opened and counted. The Chairman then declared the following elected Officers and Councillors of the R.A.S.C. for 1938:

Honorary President—The Hon. Leonard J. Simpson, M.D., Minister of Education for the Province of Ontario.

President—Wm. Findlay, Ph.D., Hamilton, Ont.

First Vice-President—J. A. Pearce, M.A., Ph.D., Victoria, B.C.

Second Vice-President—F. S. Hogg, Ph.D., Toronto.

General Secretary—E. J. A. Kennedy, 198 College St., Toronto.

General Treasurer—J. H. Horning, M.A., Toronto.

Recorder—R. H. Combs, Toronto.

Librarian—P. M. Millman, Ph.D., Toronto.

Curator—R. S. Duncan, Toronto.

Council—D. S. Ainslie, M.A., Ph.D., Toronto; S. C. Brown, Toronto; H. Boyd Brydon, Victoria, B.C.; Miss A. V. Douglas,

Ph.D., Montreal; E. A. Hodgson, M.A., Ph.D., Ottawa; Dr. G. R. Magee, London, Ont.; J. A. Marsh, Hamilton, Ont.; J. E. Maybee, Toronto; A. Thomson, M.A., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg.

On motion the meeting then adjourned.

E. J. A. KENNEDY, *for Recorder.*

REPORT OF GENERAL SECRETARY

During the last two years the policy of the Council has been to have the rolls of the Centres reflect only the active paid-up membership. For this reason the membership shows no great increase in 1937, the number now stands at 924. Our paid-up fees have increased materially in 1937 over 1936.

From the reports of the Centres there has been no lack of interest in the subject of astronomy. Attendance at meetings has been greater. As usual, our membership outside the Dominion grows steadily, an increase of 20 is shown this year.

The publications of the Society continue to be in great demand, and particularly the Observer's Handbook; it has been pronounced as the best of its kind published anywhere, and indispensable to an amateur astronomer. The Council has anticipated a large increase in the requests for the Handbook by ordering 2,500 printed.

A detailed report of the membership by centres is attached.

During the year the library has been re-decorated and refurnished, and the volumes re-classified; much credit is due to Dr. Millman for this very necessary work.

MEMBERSHIP OF THE SOCIETY, 1937

The Membership of the Society on December 31, 1937, as shown by the Reports of the various Centres, was as follows:

	1936	1937
Toronto	186	187
Ottawa	64	59
Victoria	114	126
Montreal	124	134

Winnipeg	45	45
London	51	42
Hamilton	41	44
Vancouver	43	33
Edmonton	47	43
Calgary	12	12
Members at Large	167	187
Life Members not in Centres	12	12
TOTAL	906	924
Additional Subscribers to JOURNAL	75	82

E. J. A. KENNEDY, *General Secretary.*

REPORT OF THE CURATOR

There is not a great deal to report, few requests have been made for lantern slides. Some of the telescopes have been in good service. The following is a report received from one young member, Mr. Neil McNabb, of Acton, Ontario: "Scientifically, the Society's five-inch reflector has never been used, other than for making drawings of the moon's surface, and the study of planets. For observations of variable stars it is difficult to use as there is only one very small field eyepiece. The diameter of the adapter to the eyepiece is smaller than those used to-day, and therefore suitable eyepieces are hard to obtain. In the past nine months one hundred and seventy-three visitors have been shown celestial objects through it. It is hoped that a greater number of persons will visit the telescope in 1938. I wish to thank the Society for the loan of the telescope, as it has given me an opportunity to show friends and visitors celestial objects, and possibly give them a better understanding of the universe."

ROBERT S. DUNCAN, *Curator.*

REPORT OF THE LIBRARIAN

During the past year the premises of the Society at 198 College St. have been completely redecorated and equipped with new furniture, a much needed change. The opportunity was also taken to completely reclassify all the books in the library and it is hoped

that the new arrangement will make it a little easier for members to locate the type of book they wish to consult. The writer would like to thank those members of the Society who gave him such willing assistance in moving and re-classifying the books. Especial thanks should go to Miss Budd who spent many extra hours at the library while this work was being carried out.

The Librarian acknowledges with thanks:

2 copies of "Highlights of Astronomy" by W. Bartky, presented by Mr. R. H. Combs.
"Astronomy" by Arthur M. Harding, presented by Mr. Neil McNabb, Jr.

Books of general interest recently purchased by the library include:

"Amateur Telescope Making, Advanced", edited by A. G. Ingalls.
"Sur les Autres Mondes", by Lucien Rudaux.

The latter contains many beautiful plates of the planetary surfaces.

The numbers of periodicals received during 1937 were:

From Canada and The Empire	125
" The United States	171
" Other Countries	232
Total	528

The technical periodicals are housed at the Dunlap Observatory. Among the more popular periodicals which are kept on the shelves at 198 College St. and which will be found of general interest to the members may be noted the following:

Popular Astronomy
The Telescope
Amateur Astronomy
Publications of the Astronomical Society of the Pacific
Monthly Evening Sky Map
Journal of the British Astronomical Association
Southern Stars
L'Astronomie

During the past year some of the centres of the Society have been loaned groups of books for a month or two at a time and individual members, living at some distance from Toronto, have availed themselves of the "loan by mail" service. In such ways a more general use of the library is made possible.

PETER M. MILLMAN, *Librarian.*

REPORTS FROM THE SECRETARIES OF THE CENTRES

TORONTO CENTRE

Membership as of December 31, 1937:

Resident in Toronto	135
Life Members	8
Non-resident Members	41

There were 19 new members elected and 21 removed from the rolls for various reasons, leaving a net loss of two.

During the year five council meetings and fourteen regular meetings were held. The attendance showing a decided increase over the previous year.

On January 29th, Dr. D. H. Menzel of Harvard University lectured on "Russia In and Out of the Eclipse." The lecture was held jointly with the Royal Canadian Institute in Convocation Hall, University of Toronto, and was well attended.

February 9—Dr. Helen S. Hogg: Amateurs' Contribution to Astronomy.
February 23—Mr. S. C. Brown: The Southern Constellations.
March 9—Mr. J. H. Horning, M.A.: The Meaning of Astronomical Terms.
March 23—Rev. D. W. Best: Near and Far in the Heavens.
April 6—Mr. A. R. Hassard: Some Stars I Have Liked.
Mr. R. H. Combs: Coloured Moving Pictures.
April 20—Miss F. S. Patterson, M.A.: The Realm of Nebulae.
May 4—Dr. F. S. Hogg: Solar Eruptions and Their Effect on Radio Reception.
May 18—Outdoor Meeting.
October 12—Dr. R. K. Young: Determining the Radial Velocity of Stars.
October 26—Dr. H. R. Kingston: The Way of the Moon.
November 9—Dr. C. A. Chant: The Motions of the Stars.
November 23—Mr. R. H. Combs: Coloured Moving Pictures.
December 7—Dr. P. D. McTaggart-Cowan: Forecasting Weather for Trans-atlantic Aircraft.

During the summer, arrangements were made with Dr. J. F. Heard of the University of Toronto, to conduct a class in astronomy, for the new members of the Toronto Centre. The class is held immediately after the regular meetings and to date has proved very popular.

Special mention should be made of the visit on October 12th to the David Dunlap Observatory, on the invitation of the Director, Dr. R. K. Young. The evening turned out perfect for observing and Dr. Hogg, Dr. Heard and Mr. McRae were kept busy manning the telescopes and answering the numerous questions.

F. L. HARVEY, *Secretary.*

OTTAWA CENTRE

The report of the secretary for the year 1937 is as follows:

Meetings: There was one open meeting of the centre, January 28, 1937, in which Dr. Donald H. Menzel of Harvard College spoke on the subject, "Russia—In and Out of Eclipse". There were two meetings of the council.

Membership: At the beginning of the year, the membership was 64. During the year, eight resigned, one was transferred to Montreal Centre, four members were received, giving a net loss of five. The membership now stands at 59.

Observations: Meteor observations, both visual and photographic, were planned for the Perseids in August, the Orionids in October, and the Leonids in November. Due to adverse weather conditions, two nights in August comprised the total of our observations. One good photograph was obtained.

Correspondence: The usual notices of meetings were sent to the membership. Arrangements were made for Dr. Menzel to visit Toronto and Montreal Centres as well as the Ottawa Centre in January. In March, a news letter concerning Venus, which was then very brilliant as an evening star, was distributed to the membership. Another news letter and accompanying map was sent in July, this time concerning Finsler's Comet, which for a while could be seen with the naked eye.

As in the past, and through the courtesy of the Dominion Astronomer, Mr. R. Meldrum Stewart, the new members have

received observatory star maps, while all members of the centre have received the Saturday Evening Program Bulletin.

This Centre, through the secretary, is co-operating as the astronomical unit of the local science council which is preparing for the 1938 summer meeting of the A.A.A.S., to be held in Ottawa. This council has appointed Mr. R. Meldrum Stewart as the Canadian Secretary for Section D, Astronomy.

MALCOLM M. THOMSON, *Secretary.*

MONTREAL CENTRE

During the year under review five meetings were held, the speakers being listed below.

1936, October 30—Addresses by Dr. C. C. Birchard, Mr. E. Russell Paterson, Mr. F. DeKinder.
December 4—Dr. A. Vibert Douglas: Recent Investigations of the Milky Way.
1937, January 29—Dr. D. H. Menzel, Harvard Observatory: Russia, In and Out of Eclipse.
March 5—Mr. E. Russell Paterson: Planets. Mr. O. F. Gellizeau: Universe of Stars.
April 22—Dr. Peter M. Millman, Toronto: Meteors, the Debris of Space.

Members were invited to attend the McGill Physical Society on April 23, 1937, to hear Dr. C. W. Hendel upon the Interrelation of the Sciences and Philosophy.

There are 134 members now on the rolls. New members during the year number 14.

We record with regret the death of a very old member of this Centre, Rev. A. Paterson, B.A., M.D.C.M., of Joliette, Que.

The Telescope Committee carried through a programme of weekly observational meetings during the summer on the roof of the Sun Life Building, by courtesy of the Sun Life Assurance Co. of Canada whose co-operation we appreciate.

We record with gratitude our indebtedness to the Director, Macdonald Physics Laboratory, for again extending to the Society the hospitality of the Physics Lecture Theatre for all our regular meetings.

A. VIBERT DOUGLAS, *Secretary.*

London Centre

During the year 1937, the London Centre held eight regular meetings with a total attendance of 254. A summary of these meetings follows:

January 8—Dr. H. R. Kingston: A Demonstration of the Peregrinations of Diana. Attendance 15.

February 11—Professor A. W. Foster, University of Western Ontario: Some Demonstrations of the Behaviour of Light. Attendance 35.

March 12—Dinner at Wong's Cafe. (Attendance 39).
Lecture (London Life Building), Dr. D. S. Ainslie, University of Toronto: Electrical Instruments for Astrophysical Measurements.

April 9—Professor A. E. Johns, McMaster University: Time. Attendance 43.

May 28—Outside observations at campus of University of Western Ontario, directed by Rev. W. G. Colgrove and Dr. H. R. Kingston.
Lunch at the University. Attendance 19.

October 8—Outside observations at campus of University of Western Ontario, directed by Rev. W. G. Colgrove, Dr. H. R. Kingston, Mr. T. C. Benson. Attendance 15.

November 12—Dr. H. R. Kingston: Sun Spots. Rev. W. G. Colgrove: Demonstration "Eclipses". Attendance 19.

December 10—(Annual Meeting).
Motion Pictures—1. Solar Eclipse of 1932. 2. A Trip to the Moon. 3. Natural Colour Photography.
Business Meeting—Reports of Treasurer, and Secretary for 1937, Election of Officers for 1938. Attendance 23.

The following members have also contributed to the programmes throughout the year:

Mr. J. Higgins (Current Topic Discussion)
Dr. H. R. Kingston (Constellation Study)
Mr. E. H. McKone (Constellation Study)
Rev. W. G. Colgrove (Astronomical Instruments)
Mr. O. Kilburn (A Note on the Disappearance of the Rings of Saturn)

One Executive Committee Meeting was held on December 29, 1936, to draw up a programme for the first half of the year 1937. Programme arrangements for the remainder of the year were completed by telephone.

Under the capable direction of Mr. J. Middlebrook the Observation Group of the London Centre observed and plotted the Perseid Shower of last August. Observations of the Leonid Shower in November were made impossible by adverse weather conditions. The results of the August observations have been sent to Toronto.

The total membership for the year 1937 was 42.

G. R. MAGEE, *Secretary.*

WINNIPEG CENTRE

The membership has remained practically stationary, around 45. Three members were dropped, one resigned; and we have had four applications recently.

The full programme of addresses was carried through as follows:

Professor Anderson: Measurement of Speed of Light.
Father Chabot (of St. Paul's College): Spectrum and Apparatus.
Dr. Warren (substituting for Mr. Lawson): Our Sun.
Mr. A. V. Piggott: Comets and Meteors.
Three executive members, Miss Armstrong, Dr. Bennett and G. P. Morse gave short topical addresses on the Moon.
The October "Social" was featured by an illustrated address on the Hayden Planetarium by Miss K. St. John.
Final Presidential Address by Mr. W. H. Darracott: Knowledge and Light.

There was no general observation night in spring, owing to the inconvenient absence of the planets.

The telescope has been loaned to several parties; and on the occasion of a Church Bazaar was used by some two dozen people. It is now in the possession of the Secretary.

From Mr. Colquette's running comment, a feature of each evening, the eclipse results are the principal astronomical event of the year, more particularly the aerial photographs which revised our faulty knowledge of the corona.

An executive meeting and a Nominating Committee meeting have been held. The financial position continues solvent.

G. P. MORSE, *Secretary.*

Victoria Centre

Membership: The membership at the last annual meeting was 114. During the year 3 members were transferred and resigned while 18 new members joined the centre and one was transferred to this centre. The membership then stands at present at 126. This number is subject to an estimated reduction of 9 persons who will be dropped for non-payment of dues. The membership is as follows:

Honorary	1
Life	2
Ordinary	82
Junior	18
Out of Town	23
	126

Meetings: During the year 21 meetings were held as follows: Ten regular meetings of the Centre, 4 meetings of the Council, and 7 special meetings making up the Summer Course. A high standard has been maintained in the lectures given before the Centre. The council feels specially gratified at having been able to bring before the Centre two distinguished visitors: Professor F. C. Leonard, of the University of California at Los Angeles, who lectured in the Summer Course; and Dean Buchanan of the University of British Columbia. The average attendance throughout the year was in excess of 50 persons. The short talks by Vice-President Peters, and other members, before each lecture have been of interest and value.

The Summer Course was held again this year and its continued success indicates that it is a worth while undertaking, serving to disseminate astronomical knowledge in a most efficient manner. The Centre owes a debt of gratitude to those who gave so unselfishly of their time and energies to this end. The average attendance at the Summer Course was 50 persons; there were 22 paid members of whom 8 became members of the Centre. Two prize contests were held during the Summer Course. These were of assistance in stimulating interest, especially among the new members. The Summer Course was not a financial success this year, but, in the opinion of the Council, the funds expended on this

activity were justified by the results obtained. The financial standing of the Centre is given in the Treasurer's report; it might be mentioned, however, that some 30 members are in arrears in annual dues and that payment would be a substantial help to this centre in its relations with the Federal Society.

The Council has considered and discussed matters of interest to the Centre. The question of securing a permanent home for this centre was investigated by a committee who reported that the matter was financially impracticable at the present time. It is requested that all members of the Centre keep in mind this desirable goal.

R. M. PETRIE, *Secretary.*

HAMILTON CENTRE

The Centre has held nine regular meetings during 1937, as well as three council meetings:

January	7—Dr. J. Macleod Morton, McMaster University: The Tides.
February	4—Mr. R. H. Coombs, Toronto: Moving Pictures: The Moon, Total Eclipse 1932, Jupiter's Satellites, Sunsets at Rice Lake.
March	4—Mr. J. H. Horning, Toronto: The Measurement of Planets' and Stars' Diameters.
April	1—Dr. R. E. De Lury, Ottawa: Sunspots.
May	6—Answers to written questions which had been allocated to suitable members for elucidation. Many of the twenty-five questions asked had their origin in the OBSERVER'S HANDBOOK.
June	15—Field Night at residence of Mr. W. T. Goddard (see THE JOURNAL —September, page 334).
October	7—Balance of questions tabled from May 6 answered. Refreshments provided by ladies connected with the council (through membership or marriage).
November	4—Dr. W. H. McNairn, McMaster University: Other Worlds than Ours.
December	2—Alderman J. A. Marsh, M.P.: Celestial Fireworks.

This Centre keeps up the practice of maintaining what is known as the Curtain Raiser, being ten minutes before the main address, devoted to some specified subject and given by a member. On three of these occasions, the President, Professor Johns, undertook to explain Kepler's laws, Mr. Wilfred Mallory described the current heavens, and Mr. T. H. Wingham handled some mythology in his

talks on The Heavenly Royal Family. Mr. Mallory also addressed a beginners' meeting with OBSERVER'S HANDBOOK as the text-book.

The membership has gone forward this year in numbers and in intelligence, too, to judge by the questions answered on May 6. We have had a good average attendance—a paid membership of forty-four with applications from six new candidates for next year already received.

Professor A. E. Johns has completed his second year as President and now retires from high office in favour of G. E. Campbell, B.A., one of the vice-presidents. The secretary-treasurer has appreciated the Professor's leadership as he has shown a wonderful facility for getting his scientific friends to come and lecture without expense to the Centre.

While we are still financially among the "lean and ill-favoured kine" of the centres, we have gone forward under his presidency by a dollar a meeting and if this rate is kept up, by the time some of that light reaches us from those distant nebulae, the treasurer of this centre will find that he has a million dollars to be responsible for.

N. H. BROADHEAD, *Secretary.*

VANCOUVER CENTRE

During 1937, seven regular meetings and one special meeting were held.

January —Prof. W. H. Gage: Star Clusters and Nebulae.
February —C. S. Beals, Ph.D.: The End of the World.
March —F. Dickson, Ph.D.: Life on our Planet.
April —J. C. Jorgensen: Rowland's Grating and its Mounting.
J. Teasdale: The 200-inch Telescope.
May —Annual Dinner. H. P. Newton: Life and Work of the Rev. F. W. A. Ellison.
August —Special Meeting. F. C. Leonard, Ph.D.: Visitors from Cosmic Space.
October —W. E. Harper, M.A., D.Sc.: Exploding Stars.
November —Dean Buchanan: The Red Shift of Receding Nebulae.
December —Election of Officers.

For the session 1937-38 a series of half-hour topics has been arranged as an elementary course beginning with the solar system. Topics at the first three meetings were:

October —C. A. McDonald: Evolution of the Solar System.
November—D. L. Shaw: The Earth.
December —W. H. Gage, M.A.: The Sun.

Members in good standing as of Dec. 10th number 33.

During the year there were elected	4
Transferred to Vancouver	3
1937 dues unpaid	9
Resigned	1

J. TEASDALE, *Secretary.*

EDMONTON CENTRE

The number of paid-up members is now 43. During the year six members have resigned and six more have allowed their membership to lapse. Five new members have been elected, Mr. A. A. Fredell, Mr. J. Harrington, Miss B. McAvoy, Miss A. Smith and Miss J. McDonald.

The Council met three times. There were eight regular meetings, including the Annual Banquet. The principal speakers at these meetings were as follows:

December 10—(dinner meeting) Mr. D. E. Cameron: Astronomy in the Bible.
January 14—Mr. Max Wyman: Life on Other Worlds.
February 11—Dr. J. W. Campbell: Cosmic Evolution.
March 11—Mr. C. G. Wates: The Moon in Fact and Fiction.
April 8—Mr. H. B. Doughty: Radio and Astronomy.
May 6—Mr. J. A. McLean: Time.
October 14—Dr. J. W. Campbell: Life at an Observatory.
November 11—Dr. J. R. Tuck: Astronomy without a Telescope.

At all the meetings short talks were given on current events of astronomical interest, and when conditions were favourable telescope observations were made.

A picnic was held near Mr. Wates's telescope on May 15th. Several interesting celestial objects were observed with the 9-inch reflector.

At the annual banquet on Dec. 9th the officers for 1938 were elected (these are listed on page 147).

Two student associate members have been elected under a

provisional arrangement which permits such associate members to attend meetings but not to receive the JOURNAL.

A few more books have been added to the miniature library which the Centre possesses. The Department of Astronomy at the University has commenced subscribing to the Harvard announcement cards, and these will in future be available to any members of the Centre who may be interested.

E. S. KEEPING, *Honorary Secretary.*

OFFICERS FOR 1938

The Secretaries of the various Centres have reported the following officers elected for the year 1938.

TORONTO CENTRE

Honorary Chairman—Dr. C. A. Chant.
Chairman—E. J. A. Kennedy.
Vice-Chairman—S. C. Brown.
Secretary—F. L. Harvey.
Treasurer—J. E. Maybee.
Recorder—Dr. D. W. Best.
Curator—R. S. Duncan.
Council—Dr. D. S. Ainslie, Dr. L. Gilchrist, Dr. F. S. Hogg, J. H. Horning, T. H. Mason, Dr. P. L. Millman, Rev. C. H. Shortt, Dr. R. K. Young and Past Chairmen—A. F. Miller, A. F. Hunter, J. R. Collins and A. R. Hassard.

MONTREAL CENTRE

Hon. President—Mgr. C. P. Choquette.
President—Henry F. Hall.
First Vice-President—F. De Kinder.

Second Vice-President—Dr. Julian C. Smith.
Secretary-Treasurer—Dr. A. Vibert Douglas, McGill University.
Council—Dr.A. N. Shaw; Geo. R. Lighthall; G. Harper Hall; Dr. L. V. King; Col. W. E. Lyman; O. A. Ferrier; E. Russell Paterson; J. Addison Reid; Dr. C. C. Birchard.

VICTORIA CENTRE

Hon. President—Dr. C. S. Beals.
President—Gordon Shaw.
First Vice-President—Robert Peters.
Second Vice-President—W. R. Hobday.

Secretary-Treasurer—Dr. R. M. Petrie.
Recording Secretary—Miss P. Riddle.
Librarian—Miss C. Hailstone.
Council—Capt. W. Everall; L. Hopkins; Dr. A. McKellar; W. Petrie; K. O. Wright.

VANCOUVER CENTRE

Honorary President—Dean D. Buchanan.
President—Mrs. Laura Anderson.
First Vice-President—Seto More.
Second Vice-President—C. E. Bastin.
Treasurer—H. R. Acton.
Secretary—H. W. Fowler, 4580 West 1st Avenue.
Council—G. E. Frostrup; J. C. Jorgensen; M. A. McGrath; J. W. Moore; D. L. Shaw; F. R. Stewart and E. C. Thrupp, also Past Presidents.

EDMONTON CENTRE

Honorary President—Professor J. W. Campbell.
President—C. G. Wates.
Vice-President—W. O. Coulman.
Treasurer—E. N. Higinbotham.
Secretary—Professor E. S. Keeping, University of Alberta.
Council—Dr. E. H. Gowan; Mrs. J. A. Clarke; Dr. A. M. Revell; J. A. McLean; J. G. Taylor, and Social Hostesses—Mrs. J. G. Taylor; Miss E. M. Valens.

FINANCIAL STATEMENTS, 1937

I. GENERAL TREASURER

GENERAL ACCOUNT

Receipts		Disbursements	
Balance, 1936	$1,228.54	Publications	$2,008.68
($8.14 to Southam Press Fd.)		Public Meetings	70.39
Grants received	2,270.00	Books	28.69
Fees received	1,651.00	Interest Transfer	52.50
Publications	641.68	Stamps and Stationery	303.66
Interest	156.88	Salary, Asst. Treas.-Sec.	660.00
Stamps and Stationery	32.93	Janitor	18.00
Miscellaneous	27.31	Rent	120.00
		Grants to Centres	583.00
		Miscellaneous	378.76
		Balance to carry forward	1,784.66
		(82.64 to Southam Press Fd.)	
	$6,008.34		$6,008.34

LIFE MEMBERS' ACCOUNT

Receipts		Disbursements	
Balance from 1936	$117.98	Nil	$ 0.00
Bank Interest	.64	Balance to carry forward	118.62
	$118.62		$118.62

BUILDING FUND ACCOUNT

Receipts		Disbursements	
Balance from 1936	$102.23	Nil	$ 0.00
Bank Interest	1.03	Balance to carry forward	300.76
Bond Interest	197.50		
($17.50 to be deposited)			
	$300.76		$300.76

SOUTHAM PRESS FUND

(Deposited with General Account No. 4359)

Receipts		Disbursements	
Balance from 1936	$ 8.14	Nil	$ 0.00
Bond Interest	74.50	Balance carried forward	82.64
	$ 82.64		$ 82.64

Audited and found correct, January 14, 1938.

A. R. Hassard
J. R. Collins
Auditors.

(Signed) J. H. HORNING, *General Treasurer.*

MEMO—BONDS HELD BY IMPERIAL BANK (YONGE & QUEEN) FOR SAFE KEEPING

Account belonging to	Description of Bonds	Face values	Date of maturity	Interest dates	Rate of Int.	Half year Interest	Total amount yearly Int.
Life Members' Account	1. D. of C. R TA 083071	$ 100.00	1943	Apr. 15, Oct. 15	5 %	$ 2.50	$ 5.00
	2. D. of C. R TA 083072	100.00	1943	Apr. 15, Oct. 15	5 %	2.50	5.00
	3. Can. Perm. Mtge. Cpn. L20933	100.00	1942	June 1, Dec. 1	3½%	1.75	3.50
	4. Tor. Gen. Trust, G9538	100.00	1941	June 30, Dec. 31	3½%	1.75	3.50
	5. Tor. Gen. Trust, G9539	100.00	1941	June 30, Dec. 31	3½%	1.75	3.50
	Totals.....	$ 500.00					$21.50
Southam Press Fund	1. D. of C. NE008218	$1000.00	1941	May 15, Nov. 15	5 %	$25.00	$50.00
	2. Tor. Gen. Trust, G9537	500.00	1941	June 30, Dec. 31	3½%	8.75	17.50
	3. Tor. Gen. Trust, G9540	100.00	1941	June 30, Dec. 31	3½%	1.75	3.50
	4. Tor. Gen. Trust, G9541	100.00	1941	June 30, Dec. 31	3½%	1.75	3.50
	Totals.....	$1700.00					$74.50
Building Fund Account No. 4383	1. D. of C. E014437	$1000.00	1949	Apr. 15, Oct. 15	3½%	$17.50	$35.00
	2. D. of C. NE029210	1000.00	1941	May 15, Nov. 15	5 %	25.00	50.00
	3. Can. Per. Mtge. Cpn. L15591	500.00	1940	June 1, Dec. 1	3¾%	9.37 9.38	18.75
	4. " " " " L15592	500.00	1940	June 1, Dec. 1	3¾%	9.37 9.38	18.75
	5. " " " " L20932	500.00	1942	June 1, Dec. 1	3½%	8.75	17.50
	6. " " " " L20933	500.00	1942	June 1, Dec. 1	3½%	8.75	17.50
	7. Tor. Gen. Trust G9535	500.00	1941	June 30, Dec. 31	3½%	8.75	17.50
	8. " " " G9536	500.00	1941	June 30, Dec. 31	3½%	8.75	17.50
	Totals.....	$5000.00					$192.50
	Totals for all accounts.....	$7200.00					

II. TREASURERS' REPORTS OF CENTRES

TORONTO CENTRE

Receipts		Disbursements	
Balance from previous year.	$222.42	Rentals.....	$ 67.00
Grant from Gen. Council...	159.50	Postage and Stationery.....	30.39
		Expenses re meeting.....	150.93
		Balance carried forward....	133.60
Totals.....	$381.92		$381.92

OTTAWA CENTRE

Receipts		Disbursements	
Bank Balance from 1936....	$ 83.13	Fees to Gen. Treasurer.....	$ 43.00
48 Members' Fees.....	96.00	Postage and Stationery.....	10.00
Arrears.....	61.00	Expenses of meeting.....	40.00
Grant from Gen. Council...	21.50	Advertising meeting.....	9.67
Bank interest for 1937.....	.68	Exchange on cheques.....	.43
		Subscription paid in advance for 1938 by one member and transferred to Montreal....	2.00
		Balance carried forward....	157.21
Totals.....	$262.31		$262.31

MONTREAL CENTRE

Receipts		Disbursements	
Balance from previous year.	$120.70	Fees to Gen. Treas.....	$224.00
112 Members' Fees.....	224.00	Postage and Stationery.....	23.56
Grant from Gen. Council...	105.00	Expenses re meetings.....	85.80
Bank Interest.....	4.43	Secretary.....	6.00
Donations for Lens.....	232.50	Telescope Expense.....	157.10
		Miscellaneous.....	5.81
		Balance.....	184.36
	$686.63		$686.63

LONDON CENTRE

Receipts		Disbursements	
Balance from previous year..	$151.10	Fees to Gen. Treas.....	$ 78.00
42 Members' Fees.....	84.00	Postage and Stationery.....	3.40
Grant from Gen. Council...	39.00	Expenses re meetings.....	42.09
Bank Interest.....	.53	Miscellaneous.....	12.40
Miscellaneous receipt.....	1.20	Balance.....	139.94
	$275.83		$275.83

WINNIPEG CENTRE

Receipts		Disbursements	
Balance from previous year..	$ 10.52	Rentals.....	$ 23.50
36 Members Fees	72.00	Fees to Gen. Treasurer.....	72.00
Grant from Gen. Council....	40.85	Postage and Stationery.....	9.64
Bank Interest.....	.29	Expenses re meeting.....	00.00
Handbook.....	.50	Plate for crest.....	4.00
		Repairs to telescope.....	1.00
		Handbook.....	.50
		Balance carried forward....	13.52
Totals.....	$124.16		$124.16

VICTORIA CENTRE

Receipts		Disbursements	
Balance from previous year..	$ 54.77	Rentals.....	$ 25.00
81 Members' Fees	154.00	Fees to Gen. Treasurer.....	168.00
Grant from Gen. Council...	100.00	Postage and Stationery.....	9.62
Bank Interest.....	1.05	Expenses re meeting.....	60.08
Refund Library Grant.....	5.00	Exchange on cheques.....	.40
		Grant to Telescope Making Section.....	5.00
		Summer Course.....	14.74
		Miscellaneous.....	4.50
		Balance carried forward....	27.48
Totals.....	$314.82		$314.82

HAMILTON CENTRE

Receipts		Disbursements	
Balance from previous year..	$ 5.88	Rentals.....	$ 12.00
44 Members' Fees....$88.00		Fees to Gen. Treasurer.....	88.00
Less paid in 1936..... 24.00		Postage and Stationery.....	9.25
	64.00	Expenses re meeting.....	14.90
Grant from Gen. Council...	35.00	Balance carried forward....	16.86
Bank Interest.....	.13		
Fees in advance for 1938....	36.00		
	$141.01		$141.01

VANCOUVER CENTRE

Receipts		Disbursements	
Balance from previous year..	$ 12.43	Fees to Gen. Treasurer.....	$ 64.00
29 Members' Fees.....	58.00	Postage and Stationery.....	13.91
Grant from Gen. Council...	39.00	Expenses re meeting.....	17.50
Bank Interest.....	.23	Programmes.....	7.56
2 Members' Fees (1936)....	4.00	Balance carried forward....	10.69
Totals.....	$113.66		$113.66

EDMONTON CENTRE

Receipts		Disbursements	
Balance from previous year..	$ 54.58	Rentals.....	$ 00.00
35½ Members' Fees	71.00	Fees to Gen. Treasurer.....	77.15
Grant from Gen. Council...	43.00	Postage and Stationery.....	9.00
Bank Interest.....	1.96	Expenses re meeting.....	14.88
		Books for Library.....	16.20
		Guests (at Annual Banquet)	1.50
		Exchange on H.O. Cheque (March).....	.15
		Total.....	$118.88
		Credit Balance.....	51.66
Totals.....	$170.54		$170.54

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

Observations of the Geminids in 1937

Though meteor observations of the four chief fall and winter showers were planned at the Dunlap Observatory, cloudy weather prevented the programmes being carried out except in the case of the Geminid meteors. There was a brief period of clear weather about one hour in length on one of the Orionid nights but in the case of the Leonids and Quadrantids the sky was completely overcast. Orionid observations made by Mr. Jack Grant were reported two months ago. Mr. McNabb in Acton was able to observe the Orionids for about 50 minutes and plotted one meteor. Similar results were obtained at the Dunlap Observatory. The moon was bright and made the observation of any faint meteors difficult.

Weather permitted the observation of the Geminids on two nights at the Dunlap Observatory and on three nights at Orillia. At the Observatory exposures were made with two spectrographs and two direct cameras. On Dec. 11-12 the writer was assisted in both the photographic and visual work by Mr. S. C. Brown of the Toronto Centre of the Society. On the following night Mr. Brown observed at his own station in West Toronto. Mr. Grant in Orillia

Table I—Visual Observations of the Geminids, 1937

Station	Date	E.S.T.	Total Time Observed	Meteors G	Meteors NG	Rates per hour (six observers) G	Rates per hour (six observers) NG
D.D.O.	Dec. 11-12	11.20-2.00	95 min.	16	1	35	3
		2.00-4.10	125	33	9	41	11
D.D.O.	Dec. 12-13	12.30-2.00	27	10	0	78	0
		2.00-6.00	56	19	2	71	8
West Toronto	Dec. 12-13	11.10-2.00	84	7	0	18	0
		2.00-3.10	43	7	1	34	5

Magnitude	−3	−2	−1	0	1	2	3	4	5	Totals	Mean Mag.
Geminids	1	2		6	22	28	17	13	3	92	2.05
Non Geminids					1	1	4	4	3	13	3.5

exposed the three direct cameras used in previous observations. At all stations visual observations could only be carried out at intervals when time could be spared from looking after the cameras and for this reason the rates obtained are not as good as those from continuous visual observation. The moon was bright for the first part of the night and exposures were of necessity fairly short. A summary of the visual observations is given in Table I. The first part of the table gives the rates and the second the magnitude distribution. No doubt the presence of the moon was responsible for the low rates just after midnight. There seemed to be, however, an absence of the usual number of bright Geminid meteors.

TABLE II—PHOTOGRAPHIC OBSERVATIONS OF THE GEMINIDS, 1937

Station	Date	Total Exposure Time	Meteors Photographed	Cameras
	Spectrophotography			
D.D.O.	Oct. 21-22	1.8 hrs.	..	F/4.5, F/4.5
D.D.O.	Dec. 11-12	11.8	..	" "
D.D.O.	Dec. 12-13	12.2	1	" "
	Direct Photography			
D.D.O.	Oct. 21-22	0.3	..	F/2.0
Acton	Oct. 21-22	0.1	..	
D.D.O.	Dec. 11-12	9.2	..	F/2.0, F/4.5
Orillia	Dec. 11-12	11.6	..	F/1.9, F/6.3, F/8
D.D.O.	Dec. 12-13	7.0	2	F/2.0, F/4.5
Orillia	Dec. 12-13	12.4	1	F/1.9, F/6.3, F/8
Orillia	Dec. 13-14	11.1	1	" " "

A summary of the photographic observations is given in Table II. Mr. Grant secured two direct photographs of Geminids at Orillia and at the Dunlap Observatory three photographs were obtained. These three were all of the same Geminid meteor, one being a faint spectrum of Type Y taken with the rotating shutter. Four segments show on the plate which is badly fogged with moonlight. The direct photographs were also obtained with the rotating shutter but considerable trouble was experienced with the motor owing to the cold weather so the speed of rotation was not accurately known. The meteor was not visually recorded at Richmond Hill but may have been one seen by Mr. Brown in West Toronto.

P. M. M.

REVIEW OF PUBLICATIONS

Lehrbuch der Stellarstatistik, by E. von der Pahlen. Pp. 934 + xv, 6¾ x 9½ ins. Leipzig, Johann Barth, 1937. Price R.M. 98 (96 unbound).

The purpose of this note is to call to the reader's attention a very impressive text-book of stellar statistics. A detailed review of a thousand page technical book in brief space would be impossible. The author of *Stellarstatistik,* Professor von der Pahlen of the Potsdam Astrophysical Observatory, is well known for his work on stellar motions, on the K-effect in radial velocities, and on the analysis of dark nebulosities. Professor von der Pahlen was aided in his writing of this book by Dr. Gondolatsch of the Berlin Recheninstitut, and the late Dr. Hufnagel.

The book is composed of four chief parts, dealing with the basis of mathematical statistics, the observational material, the space distribution of the stars, and the motions and dynamics of the star system.

The classical methods of mathematical statistics are outlined in considerable detail. The nature and treatment of the observational material include discussion of positions, motions, magnitudes, colours, spectra and parallaxes of the stars. The actual application of the analysis is contained in the last two (the major) sections of the book. The space distribution of the stars, both in general and according to spectral class, and also that of star clouds and dark nebulosity is analysed. Some of the statistical problems dealing with the structure of globular clusters are included, as well as a survey of the distribution of extragalactic nebulae. The section on motion analyzes solar motion, the velocity distribution of stars, and star streaming. Equilibrium distribution, star streaming and galactic rotation are finally analyzed from the dynamical point of view.

In any work of such extent the author must naturally decide which phases of the subject must be emphasized and which may be discussed more briefly. As is probably natural in a text-book, the theoretical developments here tend to be rather ideal and detailed, compared with the observational matter to which they can be applied.

In some cases it might seem preferable to treat the material by simpler if somewhat less elegant means. In general, however, the author has maintained a very fair balance in his selections.

The nature of the subject, of course, is such that a working knowledge of higher mathematics is necessary in order to follow through the arguments presented. The book will undoubtedly be of great use as a reference work as well as an advanced text-book.

F. S. H.

Our Stars Month by Month, by Mary Proctor. 92 pages, 4¾ x 7¼ ins. N.Y., Warne, 1937. Price $1.00.

In the latter part of last century Richard A. Proctor was one of the best known names in astronomical literature. He was an able student of astronomy and an accomplished writer. His scientific papers and his numerous volumes, popular but accurate, were widely read not just in England but in America and other countries. He died in 1888 while on a visit to the United States.

The author of the above book is his daughter, and in her endeavour to carry on the father's notable work has published several volumes herself. This one is intended to assist the ordinary person to recognize the stars in the sky in the same way that we recognize and welcome the common flowers of the earth.

The book explains how to use the maps, of which there are twelve, one for each month of the year; it gives the names of the stars of the first three magnitudes, with the significance of the names; it gives a list of the twenty brightest stars and the letters of the Greek alphabet; and then in succession describes the sky for each month, beginning with September. Interesting information regarding various individual stars is provided and fuller reference is made to Nova Herculis and its discovery by the distinguished English amateur astronomer Prentice while pursuing his hobby of observing meteors. The little book is of a convenient size and it is hoped that it will be specially helpful in directing our youth to the starry skies.

C. A. C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Gold Medal to Director Wright

The gold medal of the Royal Astronomical Society (of London) has been awarded to Director W. H. Wright of the Lick Observatory. From the large body of astronomical research produced by Professor Wright the committee singled out for special mention his studies on the spectra of gaseous nebulae and novae, and his work on the photography of planets.

Death of W. H. Pickering

William Henry Pickering, younger brother of the late E. C. Pickering of the Harvard Observatory, died at Mandeville, Jamaica, on January 16 at the age of 79. For a long time Professor Pickering had lived at Mandeville where he established an observatory for Harvard University. Here he carried out many investigations, largely relating to the moon and the planet Mars. Since 1893 Professor Pickering had been an honorary member of the Royal Astronomical Society of Canada.

The Great Aurora of January, 1938—its Audibility

From Mr. David J. Howell, of Berrynarbor, Devon, England, has been received a bundle of newspaper clippings regarding the brilliant auroral display of January 25-26 last.

One writer states that the display was more vivid than any he had seen since 1870, when, as a little boy living near Canterbury, he was taken out to see the brilliantly illuminated sky, which, at the time, was attributed to the burning of Paris by German troops. That display is well recorded in works on meteorology, for example in the volume by Angot in the International Scientific Series published fifty years ago.

Another correspondent, C. H. Lay, F.R.I.B.A., of Aldringham, Leiston, Suffolk, under date January 27, writes:

> In the descriptions I have read of the display of the Aurora Borealis I have not seen any mention of the curious noise which accompanied the phenomenon at about 9 o'clock.

The occurrence of any noise from the Aurora Borealis is disputed by experts but that night it was clearly evident to me when I was not expecting it. As I saw this phenomenon from open country the sound could not have proceeded from any other source.

The present writer is glad to add this to other evidence of the audibility of the aurora which he has been collecting for many years and which was summarized to date in this JOURNAL (Vol. 17, p. 273, 1923).

Among the editorial notes in the *Ilfracombe Chronicle and North Devon News* for January 28 is the following:

The aurora borealis is, scientifically explained, the reflection of the light of the sun off the ice sheet of the north polar region. It is seldom seen as far south, but in February, 1929, a month of great frost and record low temperature, it was observed in S. Devon.

How much longer will this ridiculous idea persist? "Scientifically explained"!

WHEN NORTH GOES SOUTH

In the cold winter weather it is a pleasing experience for a dweller in Ontario to be transported southward some 25° in latitude, and in what better place can one land than among the "sun-kissed fields and palm-dotted cities of Florida"? Some towns of this state receive great seasonal accessions of population and when springtime comes are almost deserted. Several larger centres of population, however, have extensive commercial interests and such are all-the-year-round cities. One of these is Miami, far to the south on the Atlantic shore. It will interest many outsiders to learn that the accepted local pronunciation of this name is *my-am'-ma,* to rhyme with panorama.

A visitor who is not remaining long in the city may profitably take a sight-seeing drive. The capable chauffeur points out some of the chief features of the city proper and then we go over the wonderful causeway to the Beach. One is impressed with the magnitude and beauty of the palatial residences, as well as of establishments of other kinds. The former home of a famous (or infamous) inmate of Alcatraz is shown, and attention is drawn to a large and exclusive apartment house which bears the name of Dr. S. —. We are informed that this man is a well-known astrologer and the author of a popular book on astrology. Apparently it pays. So many people have con-

sulted him and bought his book, in order to learn their life histories, that he was able to erect this big place. Not far off, however, were two small telescopes on a lawn with an announcement that by means of them visitors could view at night some ot the wonders of the sky without charge. Also, a short distance away, the residence of the well-known sportsman "Gar" Wood was pointed out, and behold! on it was mounted a hemispherical dome large enough for a 10-inch refractor! In still another place one is shown a beautiful property with imposing buildings, splendid palms and other trees, and glowing shrubs and flowers, all surrounded by a stone wall covered with vines, —surely half-a-century old at least; and yet we are informed that a millionaire from the north picked out a site, which was then under water, and had this establishment completed within a year!

Another outstanding feature of Miami is its Pan-American Airways airport. There one can see the mighty "clippers" about to take off for the Caribbean sea, Brazil and other southern destinations. They give one a sense of command of the air. Some seventy-five years ago a charming (not to say sentimental) little book was written by George William Curtis, entitled "Prue and I". For pure enjoyment a present-day young man or woman might well read it and its contemporary, "The Autocrat of the Breakfast Table", by Oliver Wendell Holmes. Well, the "I" of the book used to visit the Boston harbour and view the shabby-looking old trading ships from the far east, and by placing his hand on the hot hulk he would establish a mystic connection with Pacific islands with the sources of pepper and other spices, with palm groves and the brown-skinned beauties embowered in them, or with the Cape of Good Hope and the Happy Islands. In somewhat the same way, as the visitor gazes on the towering and wide-spreading airship at the landing he in imagination is borne aloft and carried away, with a speed greater than upon the wings of the wind, over the sparkling blue and green gems of the ocean's isles, over the lands of the palm and above the rugged mountains, and in a few hours is brought into a port which could be reached by a sailing or even a steam vessel in a week or a month! But the most remarkable feature of it all is that with the greatest ease this imaginative journey may be made a reality.

C.A.C.

MEETINGS OF THE SOCIETY

AT EDMONTON

October 14, 1937.—Dr. J. W. Campbell gave an account of Life at an Observatory based on his own experience at Yerkes and Victoria. He described the observational work with camera, spectrograph, meridian circle, etc., and the office work of measuring spectra, and computing radial velocities and orbits, with particular reference to the computation of the orbits of spectroscopic binaries.

November 11, 1937.—Dr. J. R. Tuck spoke on Astronomy without a Telescope. He pointed out that although astronomy was now a highly specialized and skilled study, yet a great deal of information about the universe might be gathered by anyone who cared to watch the skies and reflect on what he saw. After an account of some early types of measuring instruments, such as quadrants and cross-staffs, he discussed the practical value of atronomical work and spoke of the long history of the science from the days of the Babylonians onwards.

December 9, 1937.—At the Annual Banquet, Dr. W. H. Alexander, Dean of the Faculty of Arts at the University of Alberta, spoke on Astrology. In a happy blend of learning and humour, he traced the history of astrology from its rise in Chaldaea, through the Greeks, Persians and Romans, up to modern times. He pointed out that to the ordinary man superstition is more comforting than science, and that the second century of our era, reputed the most peaceful and happy in history, was also a time when astrology was more powerful than ever before or since. He read extracts from a modern periodical devoted to astrology, and commented on the apparently wide-spread interest in the subject even at the present day.

E. S. KEEPING, *Honorary Secretary.*

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